Arnold Schwarzenegger
Governor

MAINTAIN, ENHANCE AND IMPROVE RELIABILITY OF CALIFORNIA'S ELECTRIC SYSTEM UNDER RESTRUCTURING

APPENDIX - II

Supplier and Control Area Performance for AGC, Frequency Response, and Ancillary Services

Design Specification (DRAFT) for CAISO

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:

Lawrence Berkeley National Laboratory

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

PIER FINAL PROJECT REPORT

MARCH 2006
CEC-500-2006-035-APII
LBNL-58939

Prepared By:
Lawrence Berkeley National Laboratory
Consortium for Electric Reliability Technology Solutions (CERTS)
Joseph H. Eto
Berkeley, CA
Contract No. 150-99-003

Prepared For:

California Energy Commission

Public Interest Energy Research (PIER) Program

Don Kondoleon,
Contract Manager

Mark Rawson, Bernard Treanton, Linda Kelly,
Ron Hoffman, Don Kondoleon
Project Managers

Mark Rawson
Program Area Team Lead

Laurie ten Hope
Office Manager,
ENERGY SYSTESM INTEGRATION AND ENVIRONMENTAL RESEARCH OFFICE

Martha Krebs, Ph. D.
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

B.B. Blevins
Executive Director

Suppliers and Control Area Performance for AGC, Frequency Response, and Ancillary Services

Design Specification (DRAFT)

for CAISO

CONFIDENTIAL

Version 1.0

Date: January 13, 2003

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1. INTRODUCTION

This design specification contains the Suppliers Control Area Performance flowchart together with the calculation details for the calculation of metric, performance indices together with description of the design of the visualization infrastructure.

2. SYSTEM FLOW CHARTS – STATIC AND DYNAMIC DATA REQUIREMENTS

Figure 1 is an overall view of the application. It is self-explanatory and it includes estimates for the time needed for program execution (in seconds), per generator.

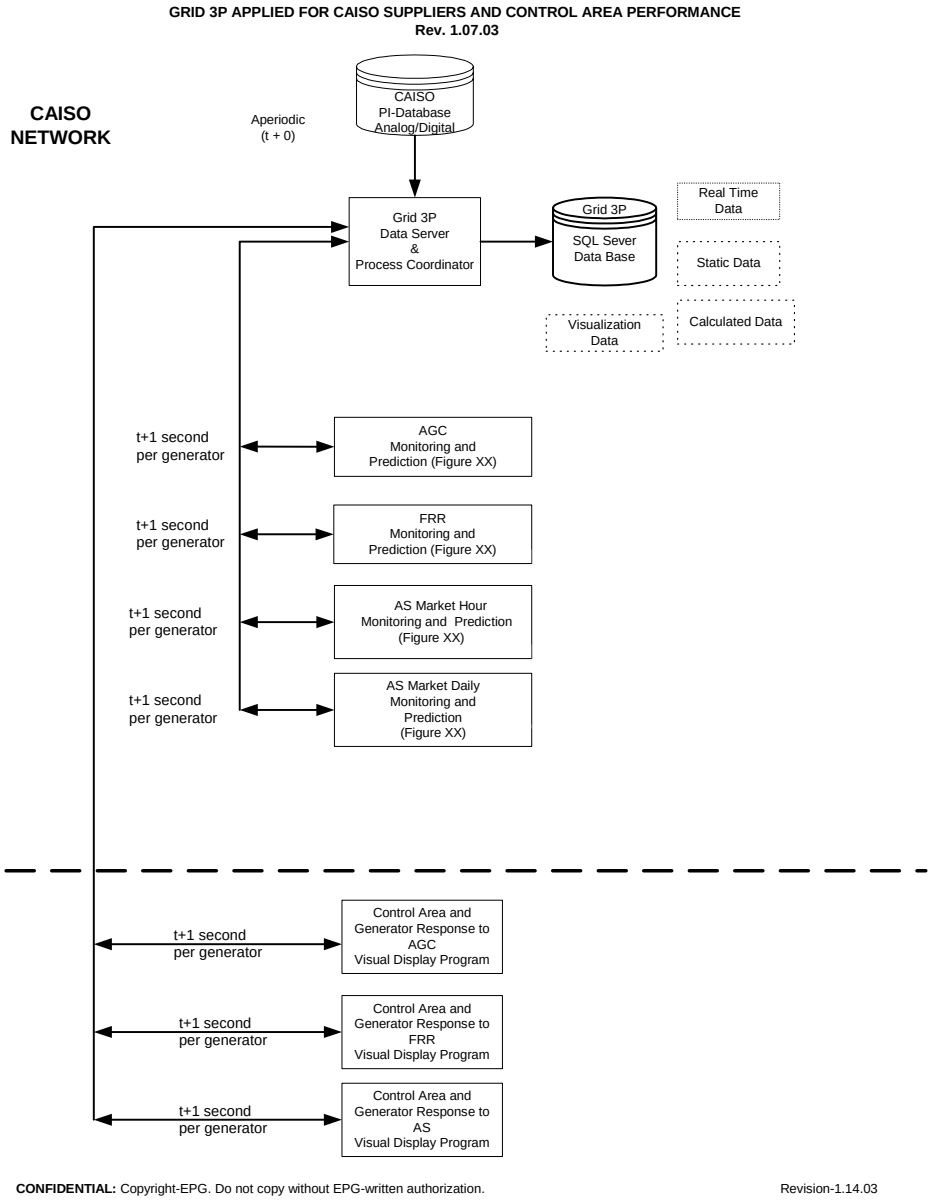


Figure 1 Overall Flow Chart

It can be appreciated in this figure that static data is needed in additional to the dynamic data obtained in real time.

2.1 Overall Program Design

2.1.1 AGC Function

One Minute
Expected MW, Actual MW, Delta MW
ACE of CA & Suppliers

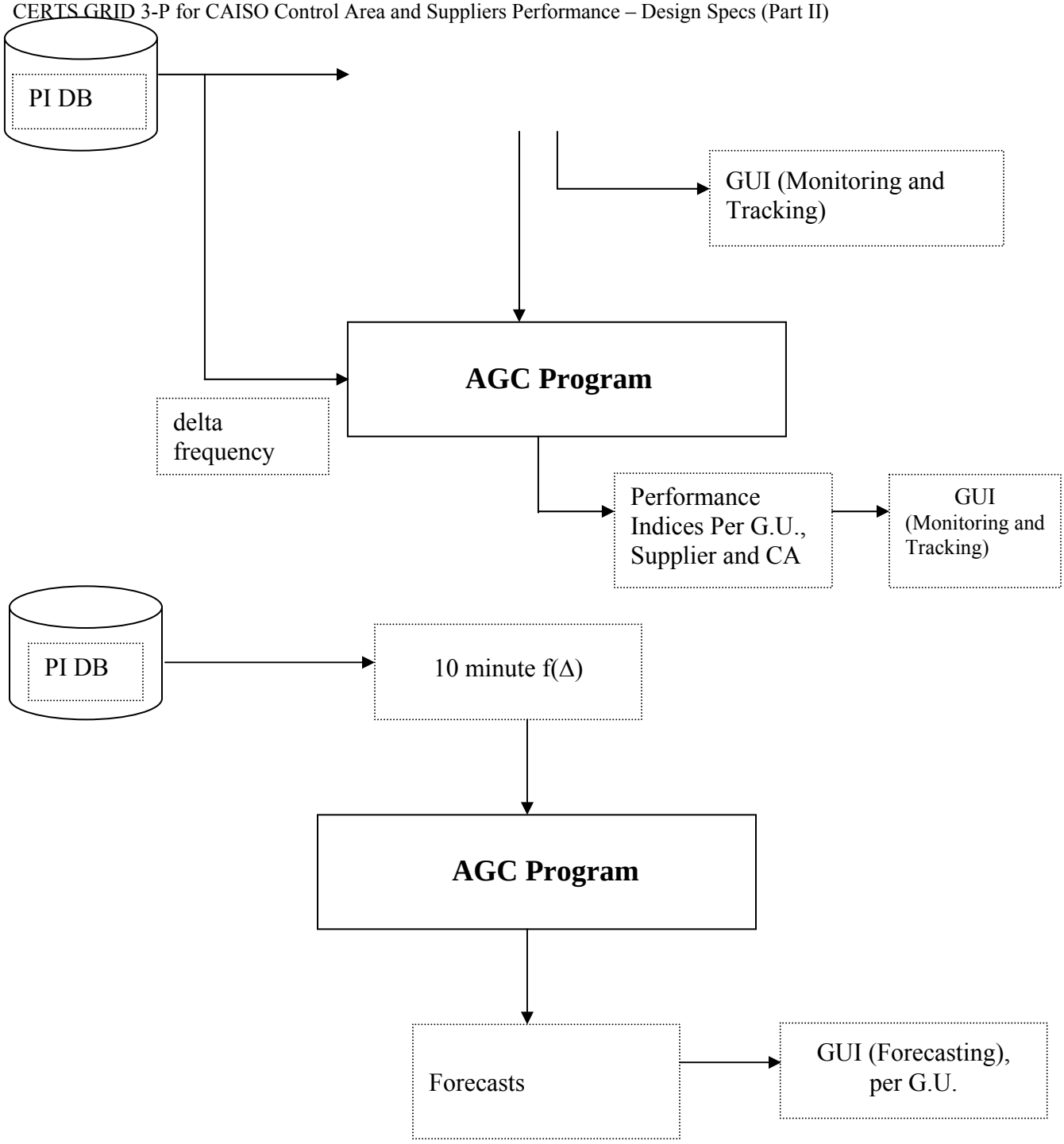


Figure 18
Overall Design of AGC Function

2.1.2 FRR Function

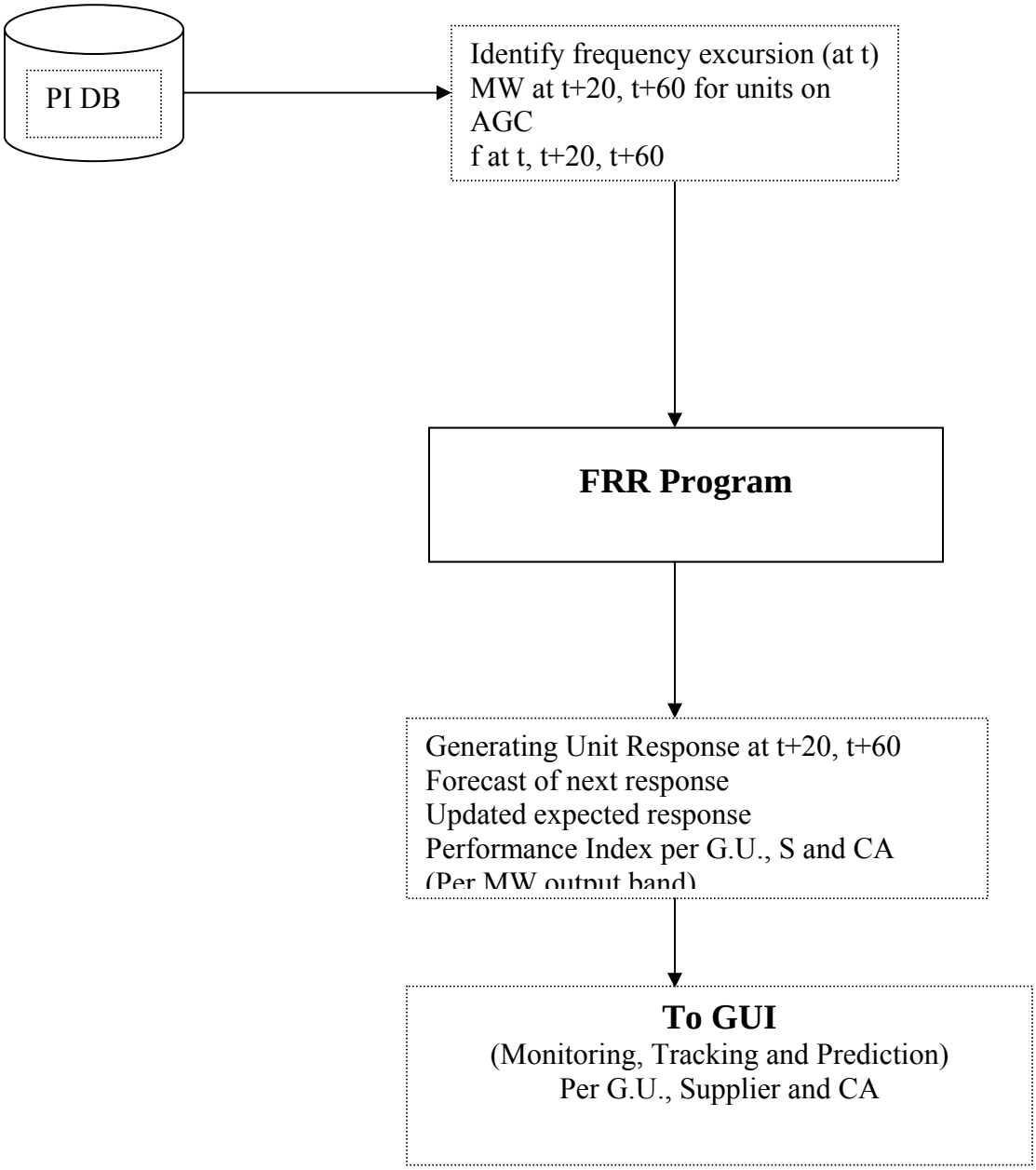


Figure 19
Overall Design of FRR Function

2.1.3 Program Design

2.1.3.1 AGC Service

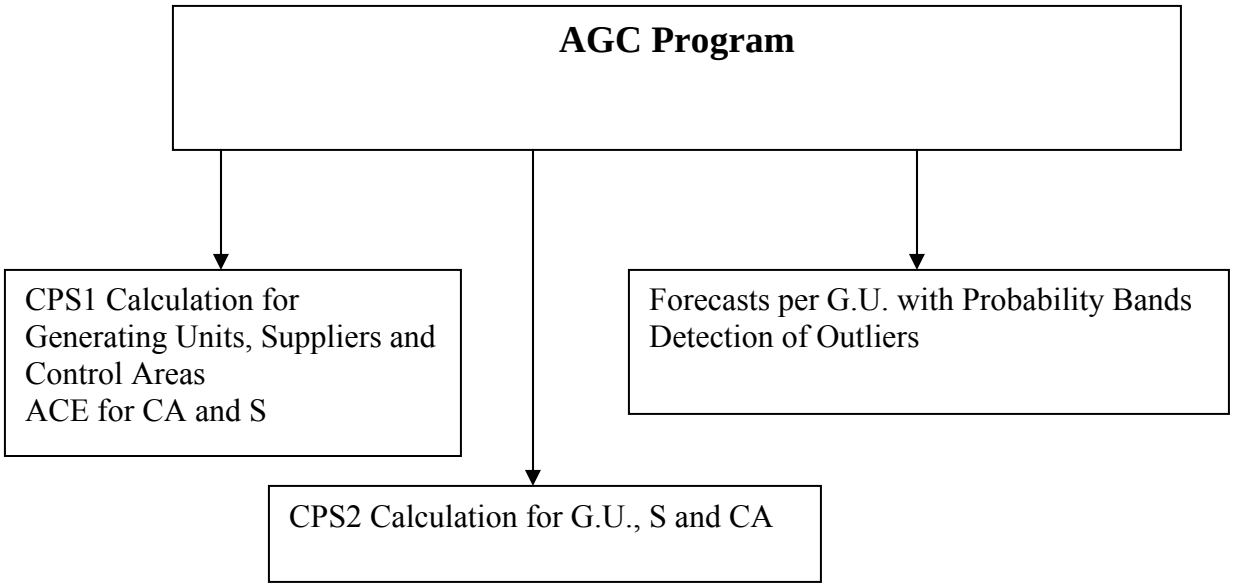


Figure 20
Design of AGC Program

2.1.3.2 FRR Program

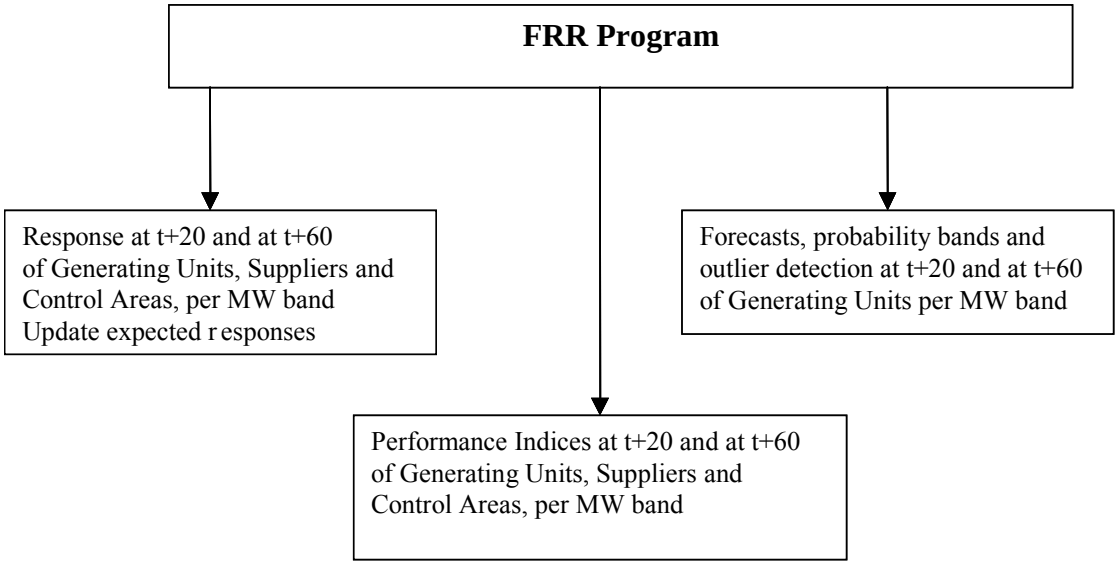


Figure 21
Design of FRR Program

2.1.4 Data Flow

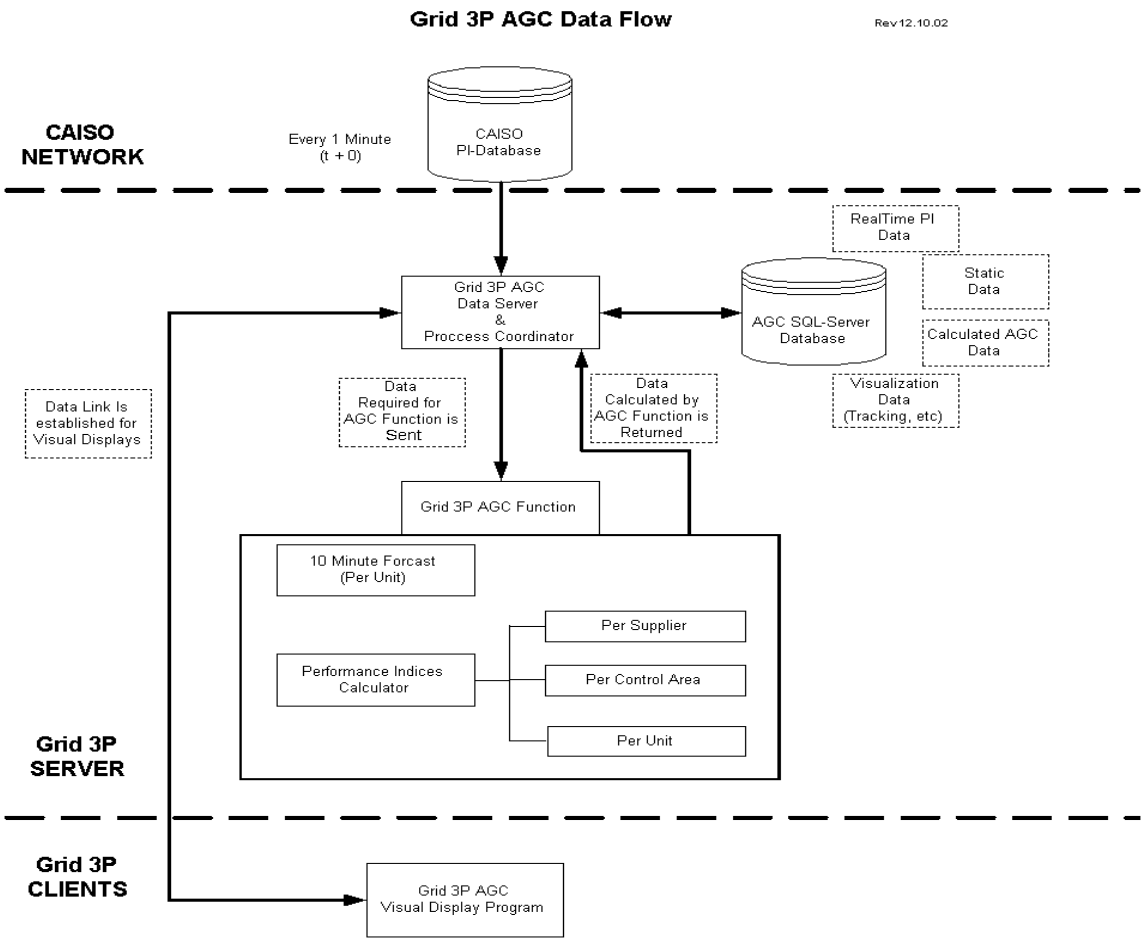


Figure 22
Data Flow

Table 1 is a listing of the static data that needs to be collected. Table 2 contains the dynamic data acquired in real time.

Table 1
Listing of Static Data

Item #	Data Description	Value	Periodicity Of Data
1	Unit/Plant (or load) name and number	Plant name and unit number	Initially during system build
2	Unit/Plant type	(Hydro/ Thermal)	Initially during system build
3	Unit/Plant Geographic Location	(North / South)	Initially during system build
4	Units/Plants per Supplier	Plant name and unit number	Annually
5	Suppliers per Control Area	Supplier name	Annually
6	ε_1 is NERC Policy 1 CPS1 limit	Hz^2	Annually
7	$\gamma_{1:}$ IOS supplier limit determined by NERC	MW^2	Annually
8	Control Area Bias	MW/0.175Hz Frequency bias term is negative	Annually
9	Bias settings of Control Areas in Interconnection	MW/0.175Hz Frequency bias term is negative	Annually
10	Target RMS of one-minute average frequency error	MW	Hour
11	Resource groupings by similar FR characteristics (i.e. hydro, nuclear, CTs)		Initially during system build
12	Load segments for FRR resources	MW	Annually
13	Expected frequency response performance of each unit/plant per output MW segment	MW/0.175 Hz	Initially during system build

Table 2
Listing of Dynamic Data

Item #	Data Description	Value	Periodicity Of Data
1	For each unit on AGC: time stamp of set points	Day, hour, minute, seconds	Aperiodic
2	For each unit on AGC: MW of set points	MW	Aperiodic
3	For each unit on AGC: time stamp of actual generation	Day, hour, minute, seconds	Aperiodic
4	For each unit on AGC: MW of actual generation	MW	Aperiodic
5	For each unit on AGC: time stamp of setpoints	Day, hour, minute, seconds	Aperiodic
6	For each unit on AGC: up and down ramps	MW/min	Aperiodic
7	Time stamp of frequency measurement	Day, hour, minute, seconds	Aperiodic
8	Frequency measurement	Hz	Aperiodic
9	Time stamp of frequency excursions	Day, hour, minute, seconds	Aperiodic
10	Frequency measurement for excursion	Hz	Aperiodic
11	MW of each FRR unit at time of excursion (t), at t+20 and at t+60 seconds.	MW	Aperiodic
12	For each Interconnection: time stamp of set points	Day, hour, minute, seconds	Aperiodic
13	Updated expected frequency response performance of each unit/plant per output MW segment	MW/0.175 Hz	Initially during system build
14	For each Interconnection: Frequency	Hz	Aperiodic
15	Next hour data – expected loading point for each resource (load and generation) and bid ramps	MW and MW/min	Hourly, 30 minutes after the hour
16	Day-ahead data – expected hourly loading for each resource (load and generation) and bid ramps	MW and MW/min	Daily at the close of the DAM (normal closing time?)

3. INPUT DATA PRE-PROCESSING

3.1 AUTOMATIC GENERATION CONTROL (AGC) SERVICE

Raw data comes from PI system. It consists for each generator on set points and actual generations. Since the PI system works on exception, these data are produced at irregular intervals of time. For this service, time is measured in seconds.

On the basis of the set points (MW) and up and down ramps (MW/min) for each generator, expected generations are produced. Figure 2 illustrates the algorithm used.

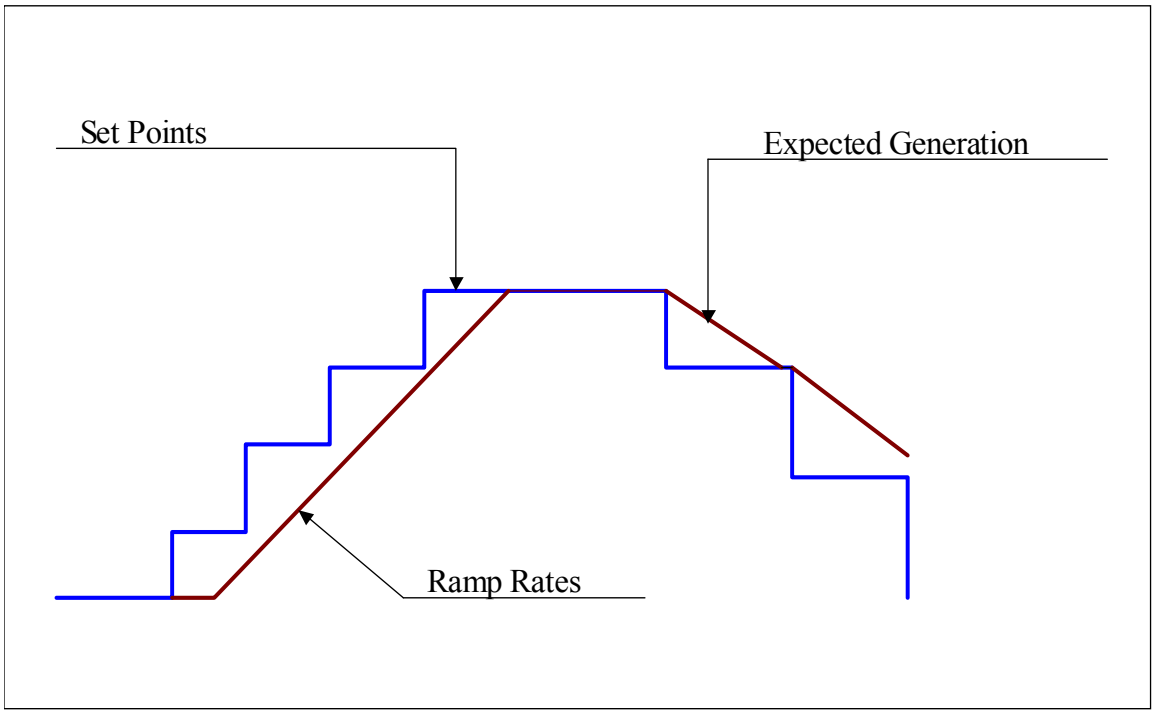


Figure 2
Calculation of Expected Generations

On the basis of expected generations so calculated and on actual generations, differences between both quantities are determined, as illustrated in Figure 3. These differences are called Supplier Control Errors (SCE).

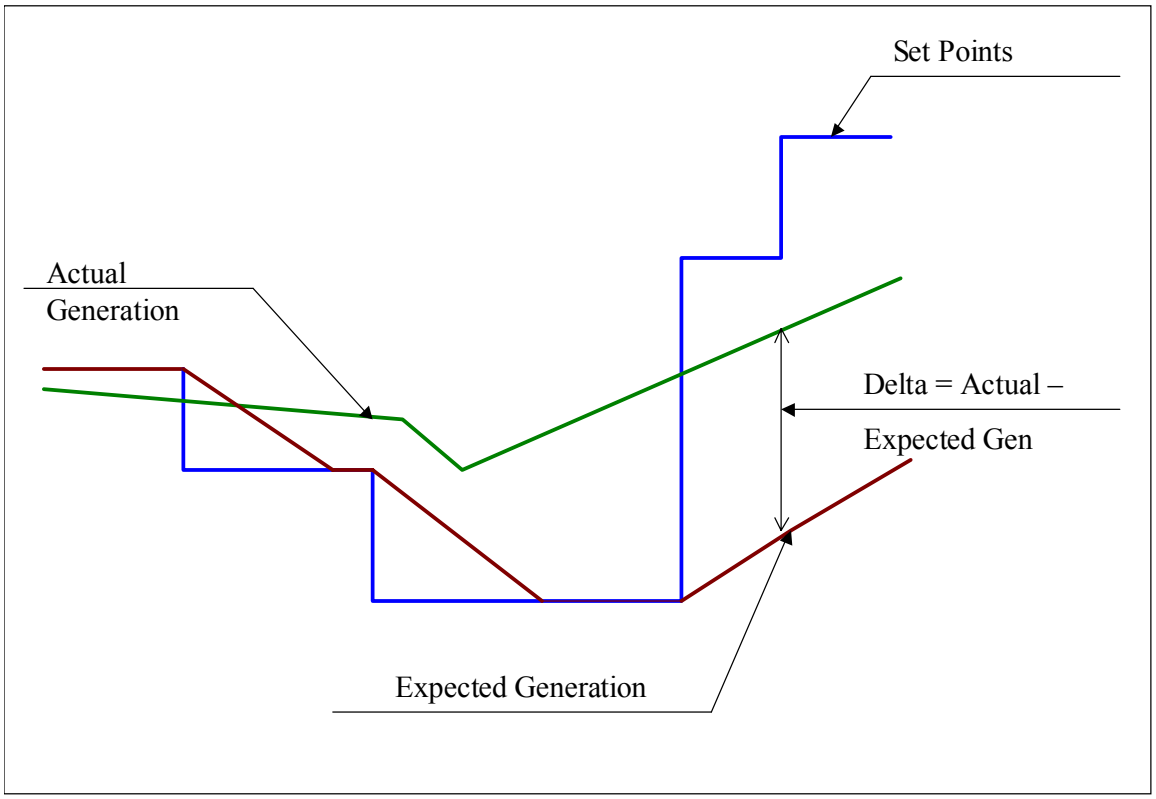


Figure 3
Calculation of Supplier Control Error

Figure 3 also illustrates the calculation of 10-minute AGC performance metrics. Two metrics are used in this application: mean of absolute values of SCE and standard deviation of SCE.

Figure 4 below presents input data (set points), actual generations (MW) and the two metrics for generating unit El Segundo. About 30 hours of data are used.

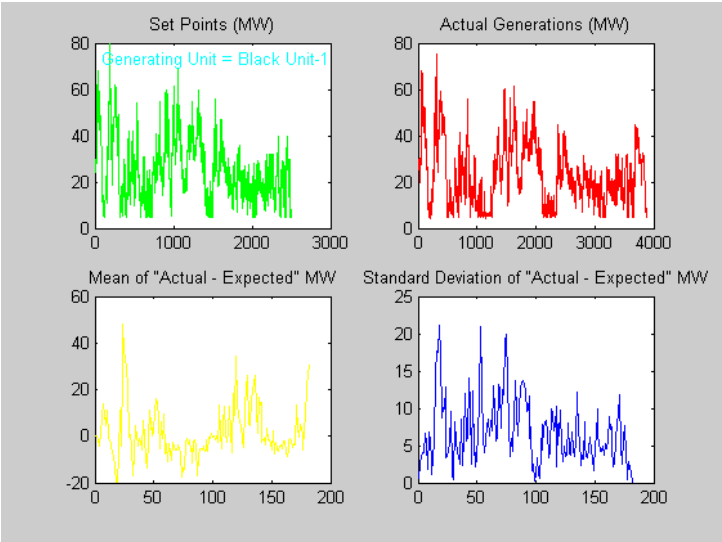


Figure 4
Set points, Actual Generations,
Mean and Standard Deviation Metrics for Black Unit 1

3.2 FRECUENCY RESPONSE SERVICE (FRR)

The following data is needed for each FRR resource and for each frequency excursion:

(1) Frequency at the time of the excursion (t), at t+20 and at t+60 seconds.
(2) Generation (MW) at t, t+20 and t+60 seconds.

The PI data base does not necessarily provide values at these time intervals. Therefore, it is necessary to perform a (linear) interpolation between the times closest to the required intervals.

The change in generation at t+20 and t+60 with respect to the generation immediately previous to the excursion, together with the change of frequency at the same time intervals with respect to the nominal frequency, i.e. 60 Hz, are converted to MW/0.175 Hz and referred to the MW output slice corresponding to the unit generation at the time of the excursion.

Suppose, for example, that the unit generation is 100 MW right before the excursion and 103 MW at t+20 and 105 MW at t+60. Suppose that the frequency is 59.90 Hz at t+20 and 59.92 Hz at t+60.

The unit response will be

(103 – 100) * (1/.10) * (.175/.175) = 5.25 MW/0.175 Hz, at t+20 seconds, and
(104 – 100)*(1/.08)*(.175/.175) = 8.75 MW/.175 Hz, at t+60 seconds.

Suppose further that the unit has an installed capacity of 120 MW and that the output ranges for this unit are as follows:

Range 1: 0 – 90 MW
Range 2: 90 – 110 MW
Range 3: 110 – 120 MW
Range 4: > 120 MW

The results above correspond to Range 2. If the expected response of this resource for this range is 6 MW/0.175 Hz at t+20 seconds and 10 MW / 0.175 Hz at t+60 seconds, the updated expected values will be:

5.62 MW/0.175 Hz at t+20 seconds, and
9.38 MW/0.175 Hz at t+60 seconds.

Notice that in taken the average, equal weights are given to the last observation and to all existing historical observations.

Unit responses can also be expressed in percentage. The value at t+20, for example, would be equal to:

(.10/60) / (3/100) = 5.56%.

4. FORECAST ALGORITHM

4.1 Formulation

A detailed formulation of the forecast engine is provided in what follows.

Let y(t) be the variable to be forecast. Assume it has a mean equal to $\mu(t)$ and slope equal to $\beta(t)$. We then have the following equations:

$y(t) = \mu(t) + \varepsilon(t);$	$\varepsilon \sim N(0, V(\varepsilon))$ (Normal distribution with given mean and variance)
$\mu(t) = \mu(t-1) + \beta(t) + \gamma(t)$	$\gamma \sim N(0, V(\gamma))$
$\beta(t) = \beta(t-1) + \delta(t)$	$\delta \sim N(0, V(\delta))$

Drop the t index for clarity and define:

$m = E(\mu)$
$b = E(\beta)$
$V(\mu\mu) = Var(\mu)$
$V(\mu\beta) = cov(\mu\beta)$
$V(\beta\beta) = Var(\beta)$

Define:

$e(t) = y(t) - (m(t-1) + b(t-1))$ (innovation)

Let matrix R =

$$\begin{bmatrix} r(1,1) & r(1,2) \\ r(2,1) & r(2,2) \end{bmatrix}$$

Using the updating equations of Kalman filtering, you can obtain the following results:

$r(1,1) = V(\mu\mu,t-1) + 2\,Cov(\mu\beta,t-1) + V(\beta\beta,t-1) + V(\gamma) + V(\delta)$
$r(2,2) = V(\beta\beta,t-1) + Cov(\mu\beta,t-1) + V(\delta)$

Let
$V(e) = r(1,1) + V(\varepsilon)$
$A(1) = r(1,1) / V(e)$
$A(2) = r(1,2) / V(e)$

We then obtain the following updating equations:

$m(t) = m(t-1) + b(t-1) + A(1)\,e(t)$
$b(t) = b(t-1) + A(2)\,e(t)$
$V(\mu\mu,t) = r(1,1) - A(1)^2\,V(e)$
$Cov(\mu\beta,t) = r(1,2) - A(1)\,A(2)\,V(e)$
$V(\beta\beta,t) = r(2,2) - A(2)^2\,V(e)$

Forecasts are made using the most recent parameter updates.

Forecast variances for future lag k are obtained recursively as follows.

$Var(k,t) = F\,VAR(k,t)\,F' + V(\varepsilon)$
$VAR(k,t) = G\,VAR(k-1,t)\,G' + V(\delta)$

Here
$F = [\,1 \quad 0\,]$
Additionally,

$$G = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

and the elements of matrix VAR(0,t) are as follows:

VAR(1,1) = V(μμ)
VAR(1,2) = VAR(2,1) = V(μβ)
VAR(2,2) = V(ββ)

Notice that once forecast variances are determined (based on the normality assumption), probabilistic statements can be made on the forecasts.

The fact that the one step ahead error forecast (or innovation) is normal with zero mean and a known variance can be used to perform a test on y(t), in order to determine whether or not it is an outlier. If this is the case, it can be replaced by the best estimate of y(t) given all the information up to t-1 which, as explained above, is:

m(t-1) + b(t-1)

The ε(t) residuals are modeled using a Box-Jenkins ARMA(2,1) model as follows:

$$\varepsilon(t) = \varphi(1)\,\varepsilon(t-1) + \varphi(2)\,\varepsilon(t-2) + a(t) - \theta(1)\,a(t-1)$$

The a(t)'s are white noise (independent, identically distributed, zero mean random variables); The φ(1), φ(2) and θ(1) parameters are updated using a Kalman filter formulation similar to the one used to update the parameters of the previously described model.

Notice that the user can interface with the models via the parameters. Suppose, for example, that he/she knows that a period of high volatility is coming up. He/she might then override model parameters variance matrix VAR(k,t) by increasing it, to reflect additional variability. This way, the parameters will update faster with the most recent observations.

Initialization is performed using historical data and usual estimates of means and variance-covariance matrices. As indicated above, the user can change the preliminary estimates of covariance matrices, in order to improve the performance of the forecast algorithm.

4.2 Performance of Forecast Algorithm

Adaptivity is a very important characteristic that the forecast algorithm should have. The algorithm was initially tested with the following types of data:

(1) Increasing observations, with constant slope
(2) Flat observations
(3) Increasing, decreasing and flat observations, with a jump
(4) White Noise (independent, identically distributed with normal distribution, zero mean observations)
(5) Flat, with two levels.

It can be appreciated in figures 5 to 9 that the algorithm adapted quickly to new conditions.

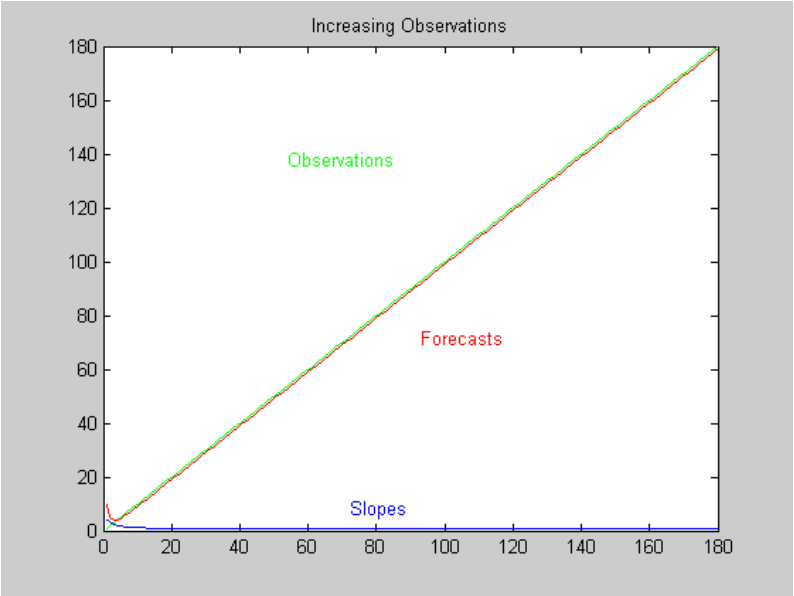


Figure 5
Increasing Observations

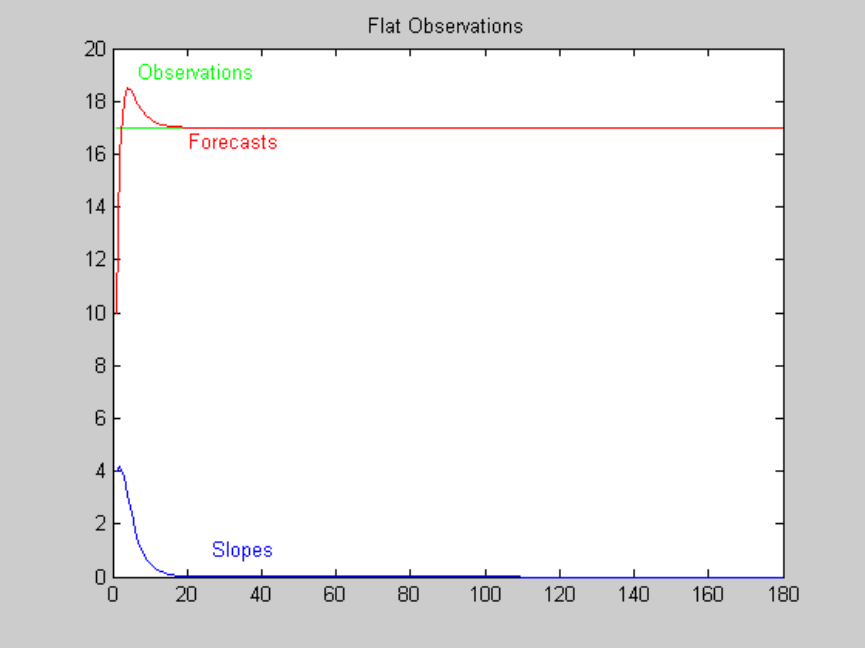


Figure 6
Flat Observations

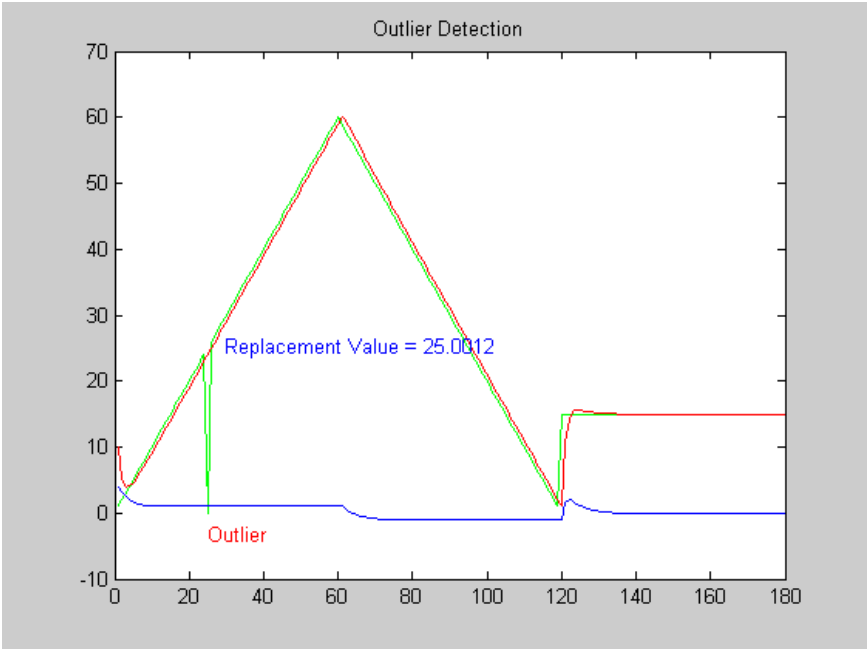


Figure 7
Increasing-Decreasing-Flat Observations

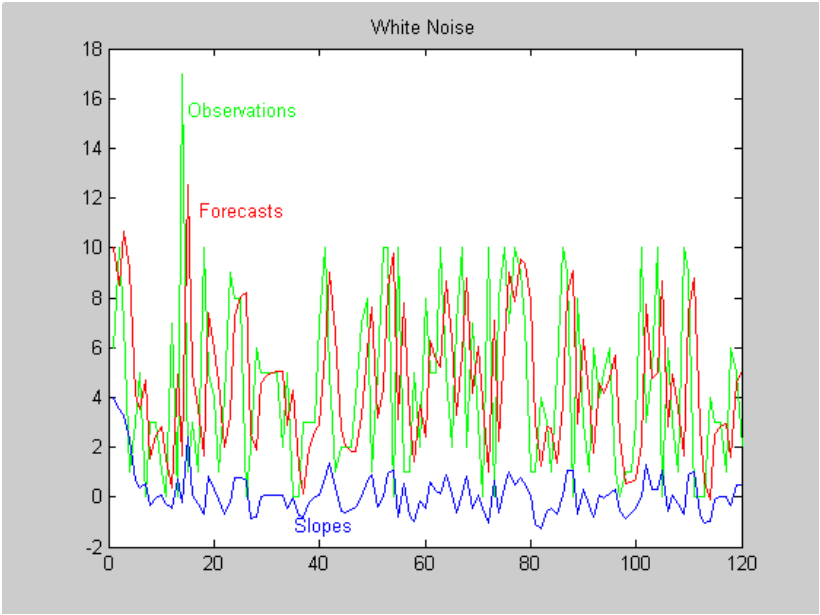


Figure 8
White Noise

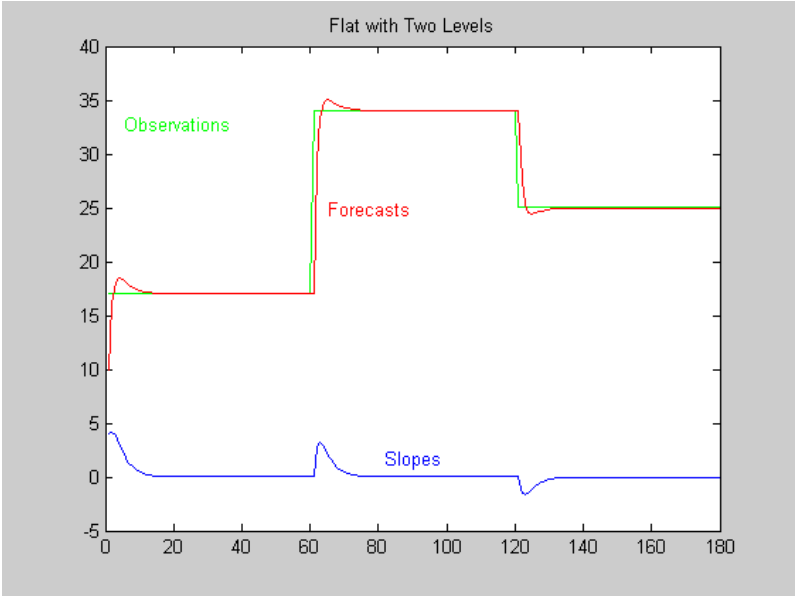


Figure 9
Flat with Two Levels

An important capability of the forecast model is outlier detection and replacing by a "reasonable value". This is illustrated for the Increasing-Decreasing-Flat case. The value 25 in the positive slope region is replaced by 0. As can be appreciated in Figure 8, the model detects the outlier and replaces it by a value close to 25.

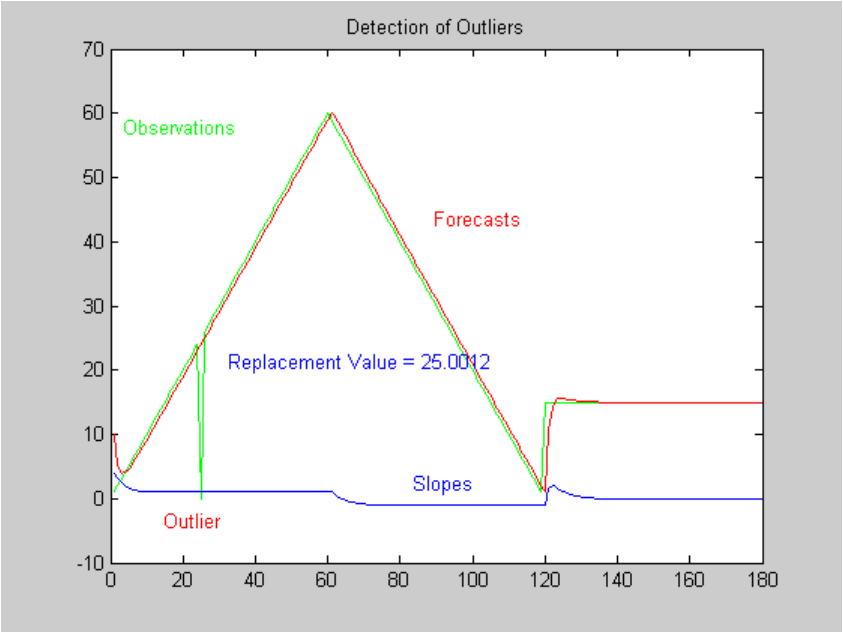


Figure 10
Detection of Outliers

4.3 AGC Preliminary Forecasts

Figure 11 permits a comparison between actual data and forecasts for 10-minute averages of SCE (Supplier Control Error) absolute values, for Black Unit 1. About 30 hours of AGC data were used.

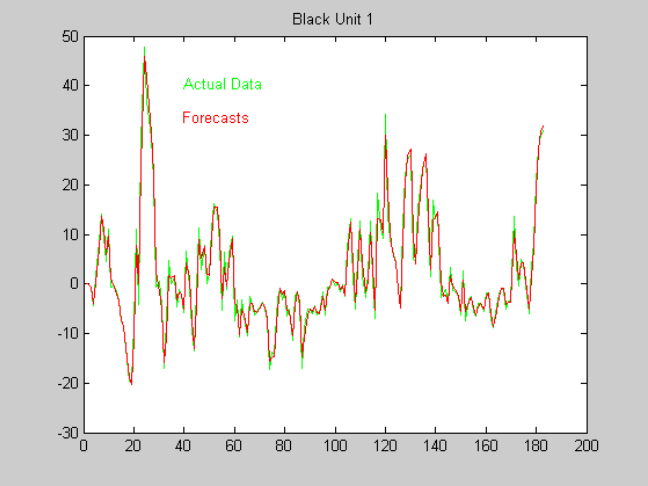


Figure 11
Actual Data Vs. Forecasts
10-minute SCE averages for Black Unit 1

For the results in Figure 11, Figure 12 below presents the one step ahead forecast errors.

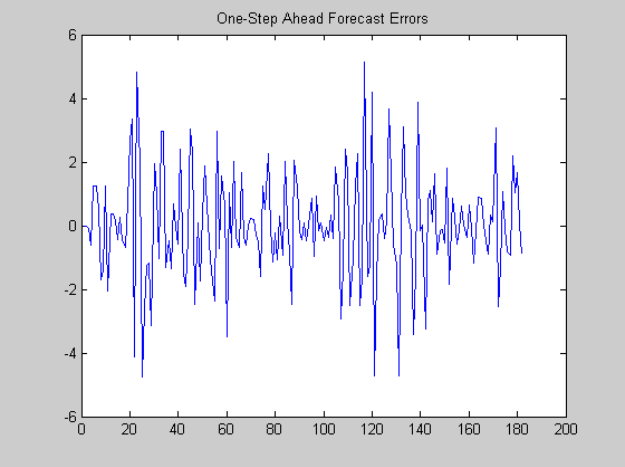


Figure 12
One Step Ahead Forecast Errors

Table 3 provides a comparison between the mean and the standard deviation of the 10-min average SCE and the forecast residuals for Black-1. Notice that the mean of the residuals is very close to zero and that their standard deviation is much lower than the standard deviation of the SCE. Forecast Error 1 in Table 3 is calculated as the standard deviation of the forecast residuals divided by the maximum SCE in absolute value. This is a usual measurement of forecast accuracy. The MAPE is determined as the average of the (absolute vale of the) one-step ahead forecast errors divided by the maximum SCE, also in absolute value. The MAPE is a widely used metric of forecast accuracy. The forecast accuracies so obtained are acceptable given the high variability of the data being forecast, as quantified by their standard deviation.

Table 3
Statistical Parameters of Forecast Errors
Black Unit 1

Model	Mean	Standard Deviation (MW)	Forecast Error-1 (%)	MAPE (%)
10-min average SCE	2.10	11.25		
Forecast Residuals	0.0137	1.70	3.55	2.61

For this particular case, no noticeable improvement in the forecasts was observed when the residuals are modeled by an adaptive Box-Jenkins model.

A similar analysis was made for generator El Segundo. The results are summarized in figures 13-15 and Table 4. They confirm the conclusions obtained for Black Unit 1.

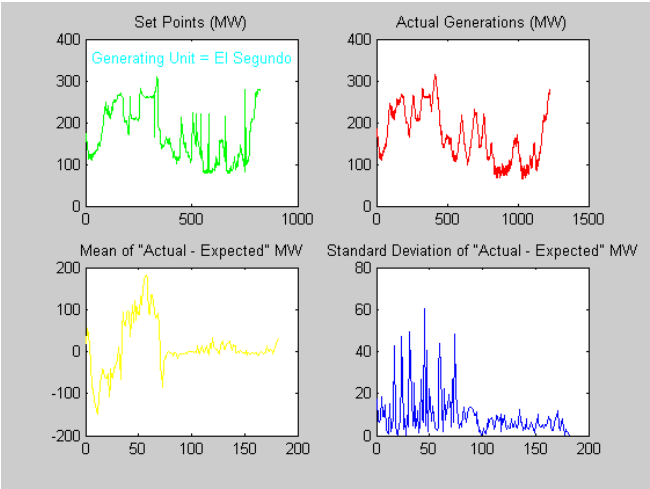


Figure 13
Set points, Actual Generations,
Mean and Standard Deviation Metrics for
El Segundo

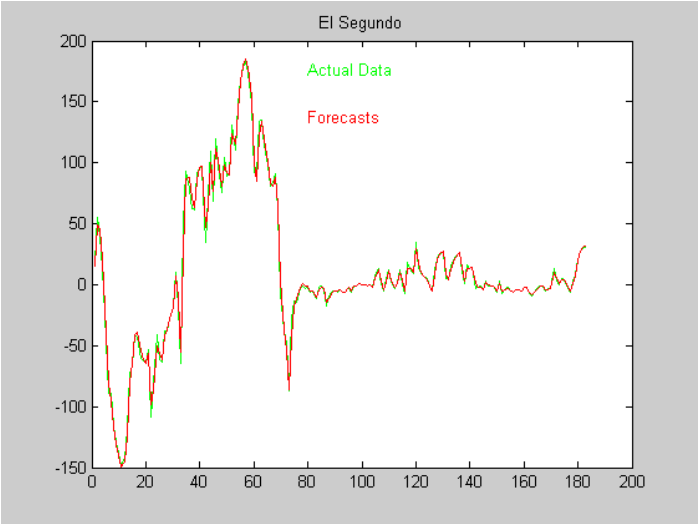


Figure 14
Actual Data Vs. Forecasts
10-minute SCE averages for El Segundo

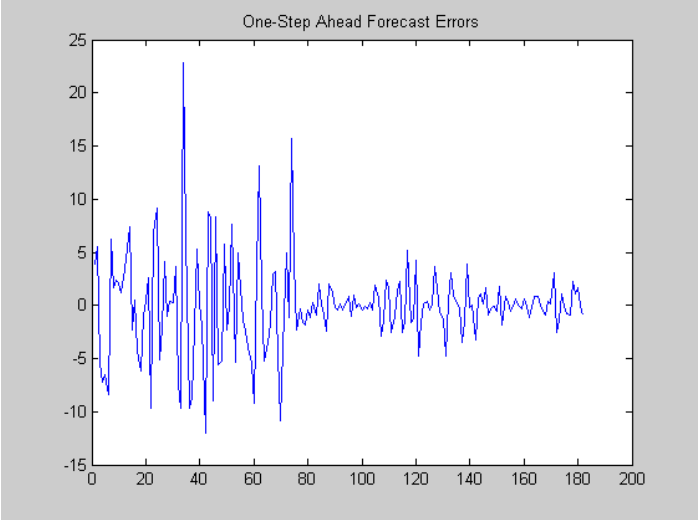


Figure 15
One Step Ahead Forecast Errors

Table 4
Statistical Parameters of Forecast Errors
El Segundo

Model	Mean	Standard Deviation (MW)	Forecast Error-1 (%)	MAPE (%)
10-min average SCE	21.96	90.43		
Forecast Residuals	-0.1663	6.30	3.44	2.73

4.4 FRR Preliminary Forecasts

4.4.1 Frequency Response at t + 20

Figure 16 and Table 5 present the results of the forecast algorithm for the frequency response at t + 20 of generator Colgate. Frequency excursions were defined for differences in absolute value above 45 mHz, with respect to 60 Hz. Figure 17 and Table 6 present the same results for the frequency response at t + 60.

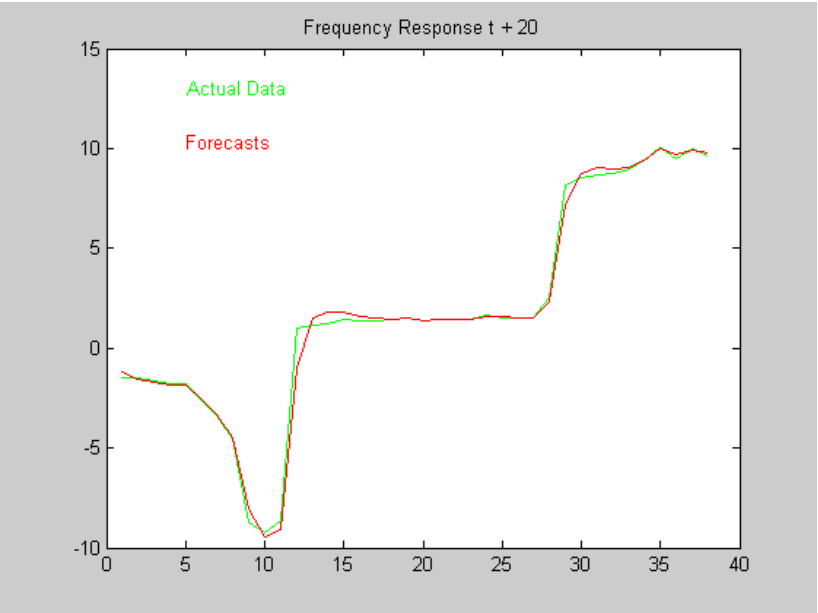


Figure 16
Actual Data Vs. Forecasts
Frequency Response at t + 20

Table 5
Statistical Parameters of Forecast Errors
Frequency Response at t + 20

Model	Mean	Standard Deviation (MW)	Forecast Error-1 (%)	MAPE (%)
Frequency Response at t+20	1.873	5.29		
Forecast Residuals	0.000379	0.421	4.18	2.20

4.4.2 Frequency Response at t + 60

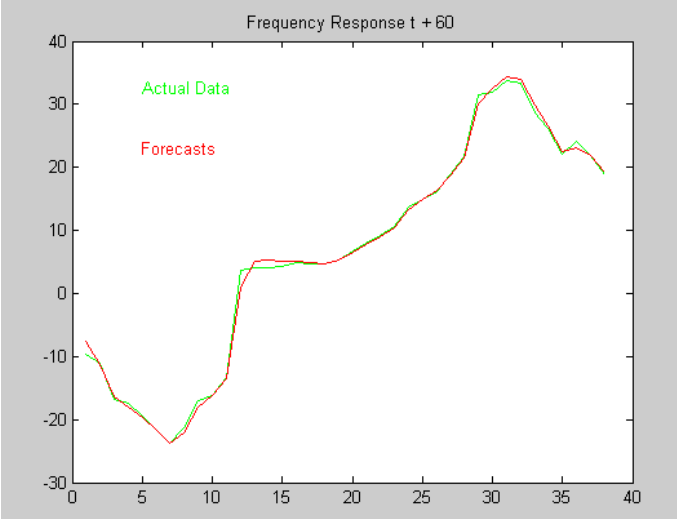


Figure 17
Actual Data Vs. Forecasts
Frequency Response at t + 60

Table 6
Statistical Parameters of Forecast Errors
Frequency Response at t + 60

Model	Mean	Standard Deviation (MW)	Forecast Error-1 (%)	MAPE (%)
Frequency Response at t+20	6.31	17.64		
Forecast Residuals	-0.0228	0.778	2.30	1.51

5. Visualization Infrastructure

5.1 Introduction

This document details out the functional aspects of the User Interface for the Monitoring, Tracking and Prediction System for AGC, FRR & AS. The different modules of the system will be explained with the proposed GUI, the data sources, the backend database and the user interaction. At the outset, for clarity the main terminology used with reference to the system would be -

- *Service* : AGC, FRR or AS (hour), AS (Day)
- *Function* : Monitoring, Tracking, Prediction; applicable to each of the above mentioned services.

The behavior of the system will be explained with reference to the context in each of the service/function scenario.

6. General AGC, FRR & AS GUI Layout

Figure 1 shows the general layout of the GUI. The screen is divided mainly into 3 panels for graphic display and a panel at the bottom for text data and a horizontal dynamic scrolling bar for displaying the performance indices in real time. The graphic panels are identified as 'Main

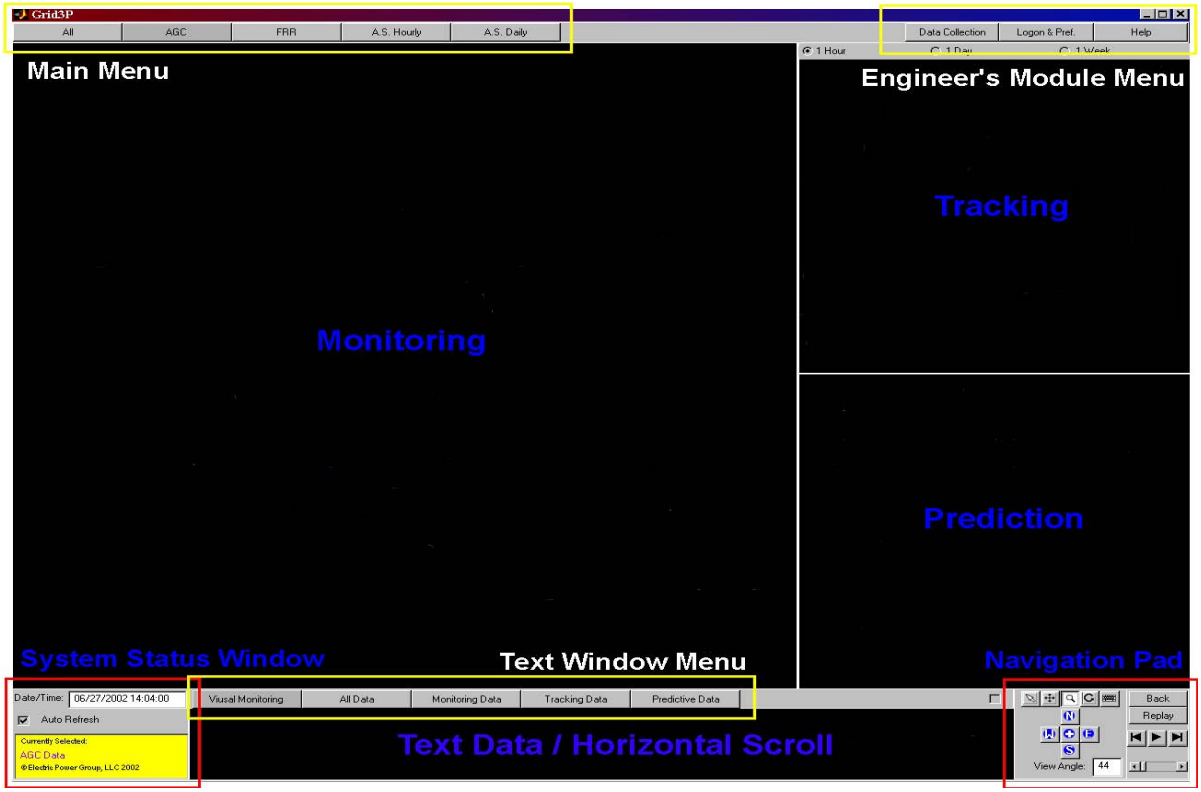


Figure 1. Functional display in a 3-panel GUI with menu layout

Panel' (MP) the larger panel on the left, 'Right Top Panel' (RTP) the smaller top panel on the right and the 'Right Bottom Panel' (RBP) the smaller bottom panel on the right. Each of these panels can be maximized to occupy the entire panel graphic area, by which the user can have a look at any particular function in greater detail. This is done through the Right Mouse Button (RMB) menu.

The 'Main Menu' allows the user to select a service (AGC, FRR, AS Hourly or AS Daily). For each service the graphic (plots) is displayed in the 3 graphic panels. 'Monitoring' will be displayed in MP, 'Tracking' will be displayed in 'RTP' and 'Prediction' will be in RBP. All the relevant text data will be shown in the text window contextually. In this window the user can view the data of each of the function of the service by selecting the text window menu or see the real time animation of the performance indices as horizontal scrolling graphical plots. Both these windows are shown later in figure 13.

In addition there are two small windows at the bottom on the either side of the Text Window. The one on the left called 'System Status Window' displays the current date and time, name of the service for which the data is being displayed, the copyright statement and the 'Auto Refresh' option – which allows the system to update the data in real time. Figure 2 shows a snap shot of this window.

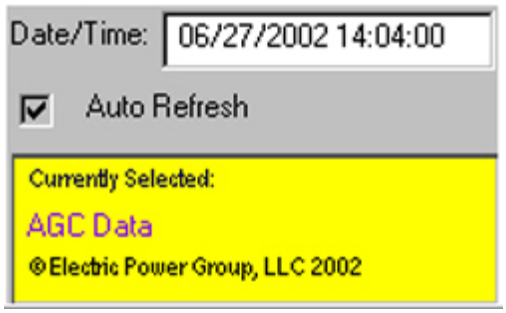


Figure 2. System Status Window

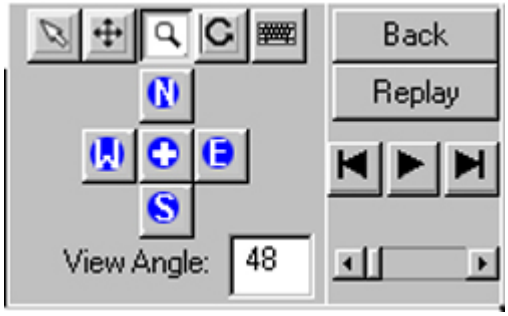


Figure 3. Navigation Pad

The small window to the right displays the 'Navigation Pad' and the 'Replay' widget. The navigation pad allows the user to interact with the graphic in any of the panels – zoom, select, pan, orient, zoom all, viewing direction vector, etc. The replay widget allows the user to select the time period for which the selected service needs to replay from the archived data. Figure 3 shows the navigation pad.

At the top left is the 'Data collection module'. This allows the engineer / supervisor to view what-if scenario data. The engineer can plug-in data and simulate the system to study its behavior. This feature is explained in detail in section 8.0.

The discussion in the following sections will throw more light on the panels and menu.

7. All Services Display

As shown in Figure 4, this display will show the comprehensive monitoring status for all the services on a single screen. The AGC will be displayed in MP, FRR in RTP and AS (Hour/Day) in RBP.

8. Data for AGC

The data will be in 2 sections :

Static – the data regarding Supplier/Plant/Generating Units, which is constant

- Unit / Plant (or load) name and number [200 Gen Units]
- Type - Thermal / Hydro
- Geographic Location – Latitude & Longitude (North / South)
- Suppliers and the total number plants and total number of units per plant (Plant Name and Unit number)
- Suppliers per control area (Names)
- Any constants and policies regarding the response rates, performance indices

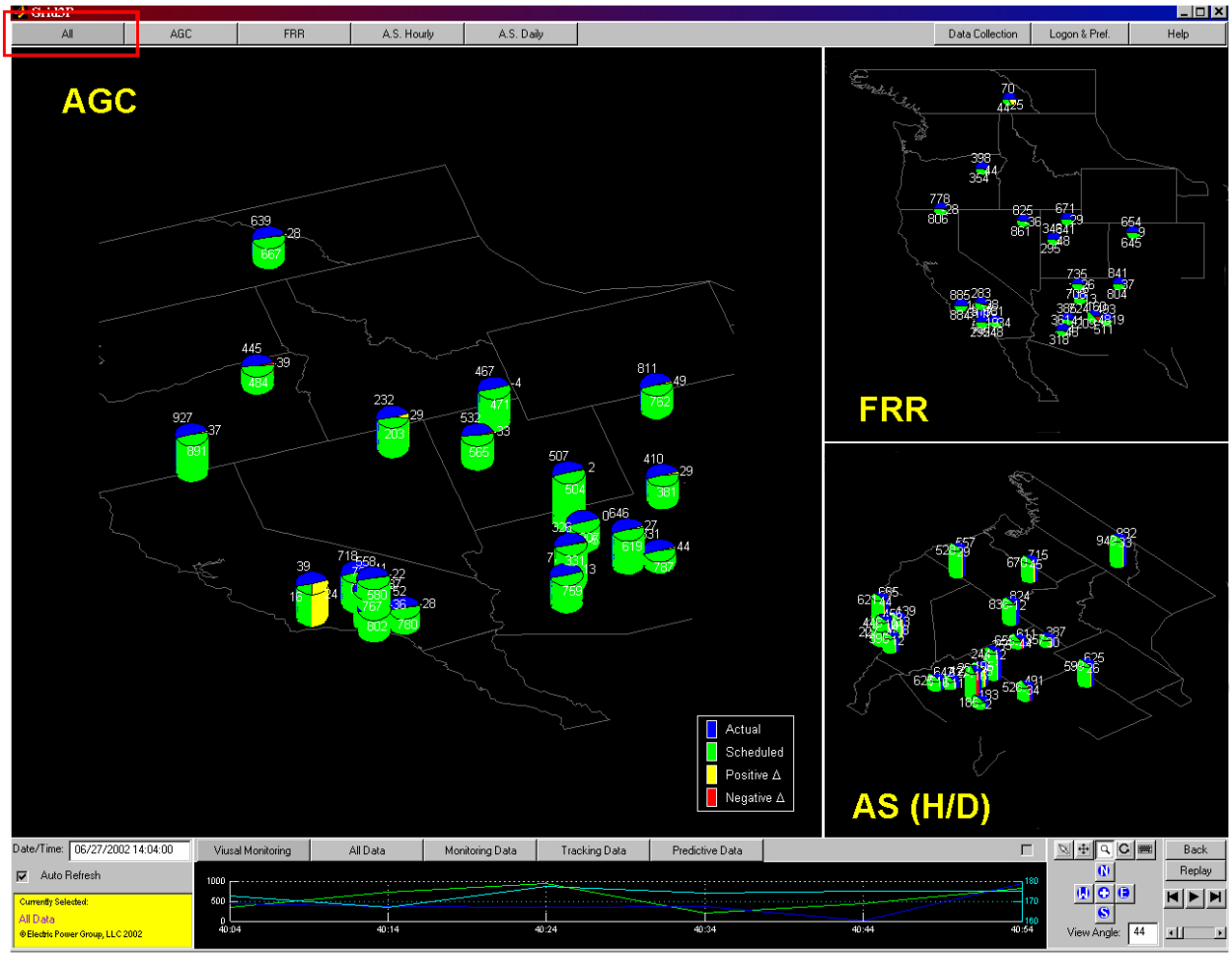


Figure 4. Monitoring status for all the services

Dynamic – the time dependent data which is collected at different time intervals or computed into groups after getting the raw data

- Expected values for each unit (MW) [0-1000MW]
- Actual values for each unit (MW) [0-1000MW]
- Time stamp of expected value for each unit (Day, h/m/s)
- Time stamp of actual generation for each unit (Day, h/m/s)
- Mean (Actual – Expected) (MW) [0-1000MW] of 1 min. data
- SD (Actual – Expected) (MW) [0-1000MW] of 1 min. data

The database design required to support this data is explained in section 8.0.

9. AGC Monitoring Display

The typical screen of AGC monitoring would be as shown in Figure 5.

In the monitoring panel the Expected (E-MW) and Actual (A-MW) output of the generating unit will be displayed in the monitoring panel as the two halves of a circle centered at the Lat/Long of the generating unit/plant. This display is called the pie-graph. Both E-MW and A-MW form the semi circles and fill the sector based on the values displayed as the percentage of the set point. Ideally both the semi-circles should be filled. Any discrepancy will be shown as a sector instead of a full semi circle (this is mostly for the actual generated value)

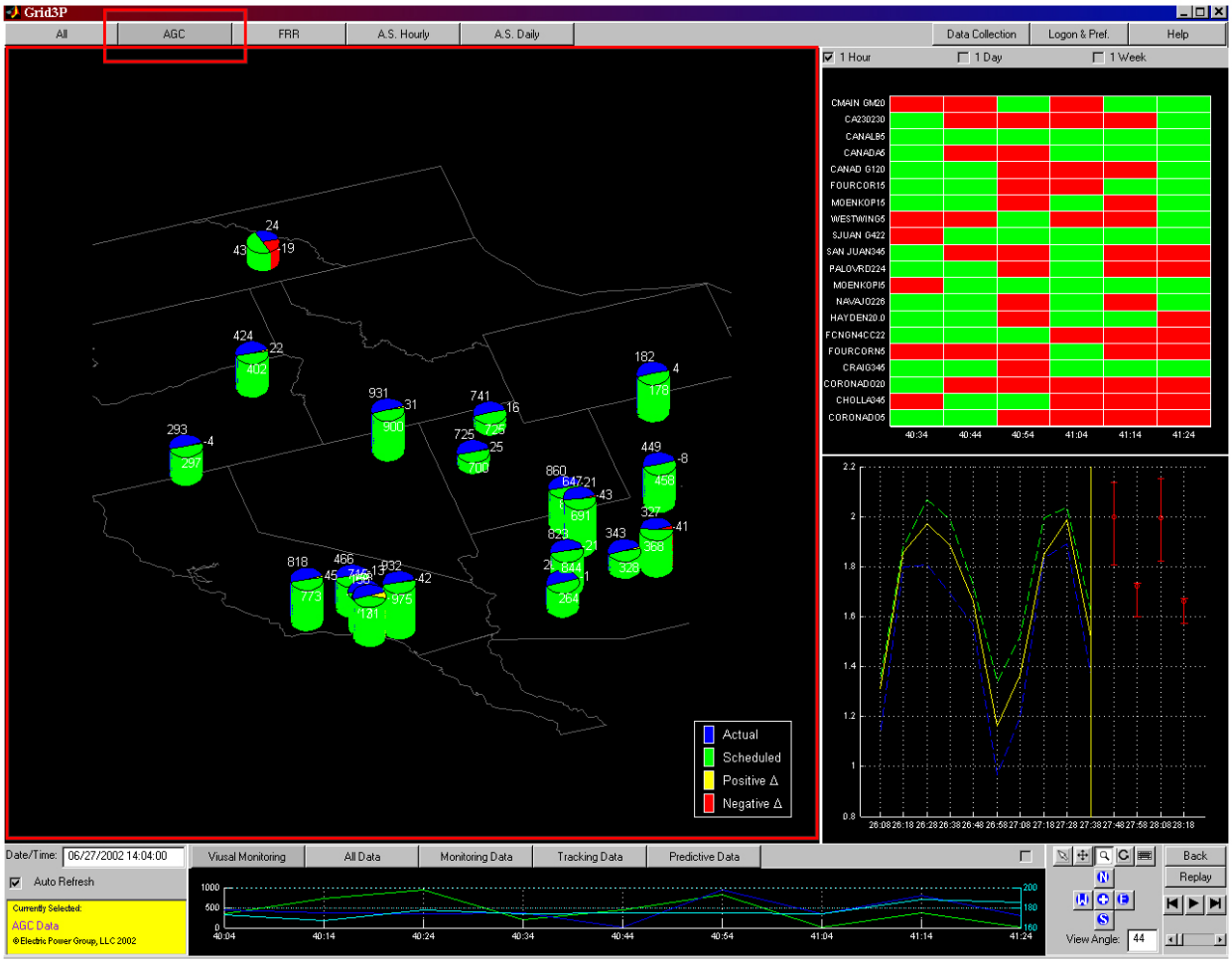


Figure 5. AGC Monitoring Display

These pie-graphs will be displayed based on a variety of selection criteria chosen by the user through the RMB.

- Entire Control area (all generating units of both types of all suppliers in all geographic locations)
- Geographic locations – North or South
- A supplier
- Thermal or Hydro
- A plant of a supplier
- Any individual generating unit within a plant

This selection criterion will be based on multiple-choice criteria. The user can select any of the check boxes from the above. The complete menu structure of the AGC Monitoring RMB will be as shown in Figure 6.

Once the generating units have been selected, then comes the issue of displaying their performance by a Performance Index (PI). There is more than one type of PI for the AGC service. The magnitude of PI is shown as the height of pie-graph. The default PI will be first listed PI type for each service/function in the configuration file. The user can choose the other type of PI using the RMB.

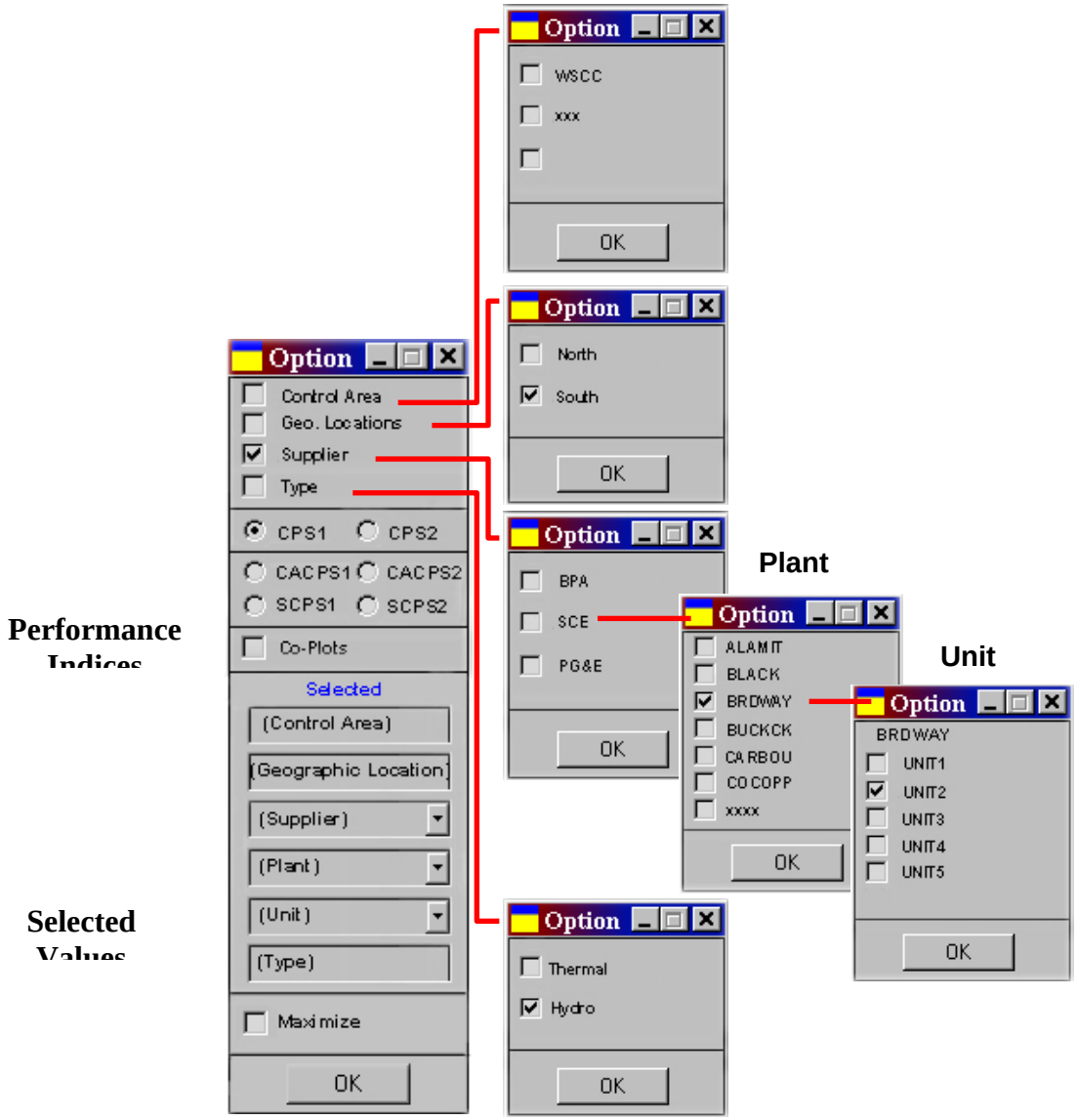


Figure 6. Right Mouse Button Menu Structure for AGC

Since there is no information displayed of the generating units on any of the panels, there will be a point- and-click selector which will show all the information of a generator like – name, type, supplier, lat/long, expected, actual, PI (based on the type of PI shown), etc in a pop-up yellow window in the proximity of the selected generating unit.

Figure 7 describes this context of the system.

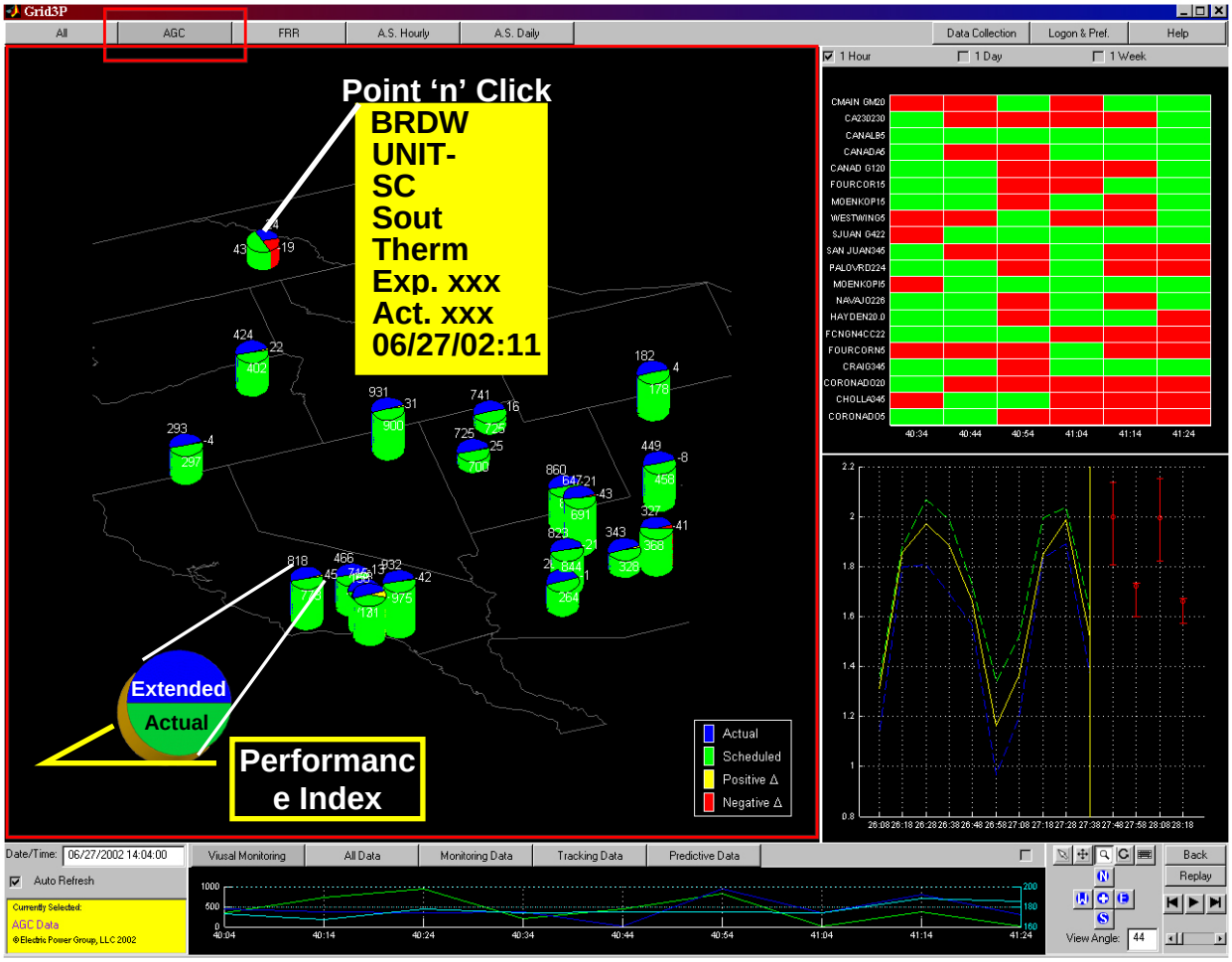


Figure 7. AGC Performance Index and Generating Unit Information

10. AGC Tracking Display

Tracking information will be shown for 3 different time intervals : 1 Hour, 1 Day and 1 Week from the historical data from the current time backwards. The Performance Index (PI) type of tracking data will have to be computed dynamically based on the interval chosen from the 1 min data available in the dynamic data source. The plot is an E-Mesh with the Generation Units on the Y-Axis and the time units on the X-Axis. Figure 8. shows the E-Mesh tracking plot. The data plotted is either the Δ (Actual – Expected) or the Performance Index, selectable using the RMB. The rules to do this is as follows:

1 Hour : show the X-Axis at 5 min intervals – avg., the 1 min values over a 5 min intervals. So for every hour there will be 12 segments on the X-Axis.

1 Day : show the X-Axis at 2 hr intervals – avg., the 1 min values over a 2 hr intervals. So for every day there will be 12 segments on the X-Axis.

1 Week : show the X-Axis at 1 day intervals – avg., the 1 min values over a 1 day intervals. So for every week there will be 7 segments on the X-Axis.

The user selects time intervals through the check boxes at the top of the top right panel.

The historical tracking data will have to be stored for 1 week. At the end of each day the weekly data is updated by deleting the oldest day's data from the set of 7 days and appending the latest 1 day's data to the set.

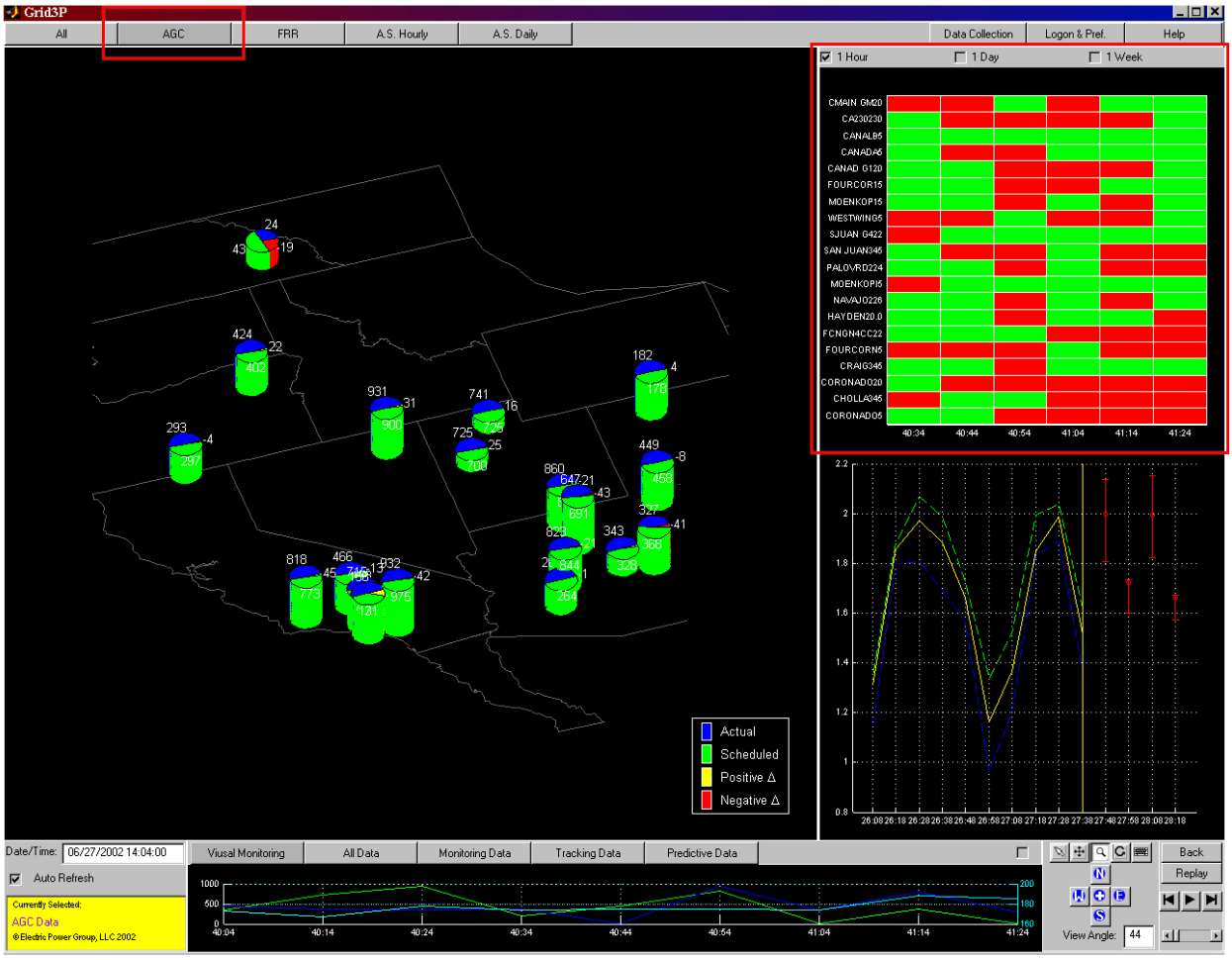


Figure 8. E-Mesh plot display for AGC Tracking

The RMB for AGC tracking would allow the user to switch the PI from CPS1 to CPS2 or vice versa. The number of generating units displayed at any given time will be 40. This is to avoid

crowding in the smaller RTP. However, when the panel is maximized one can see the tracking data for all the generating units.

11. AGC Prediction Display

The prediction data is made available as Mean or SD of Actual - Expected at 10 min intervals. The plot will show the following for any one of the selected Generating Units in the bottom right panel:

- Actual values for last 6 hours (36, 10 min values) from the current time
- Predicted values for the last 6 hours (as above)
- Prediction for the next hour at 10 min interval as well as probability bands with upper and lower values.

The user can select the generating unit from the monitoring display or a RMB can be provided. When the prediction is displayed the selected Generating Unit will be highlighted both in the monitoring panel and the tracking panel. Figure 9. shows the state of the display in the prediction mode.

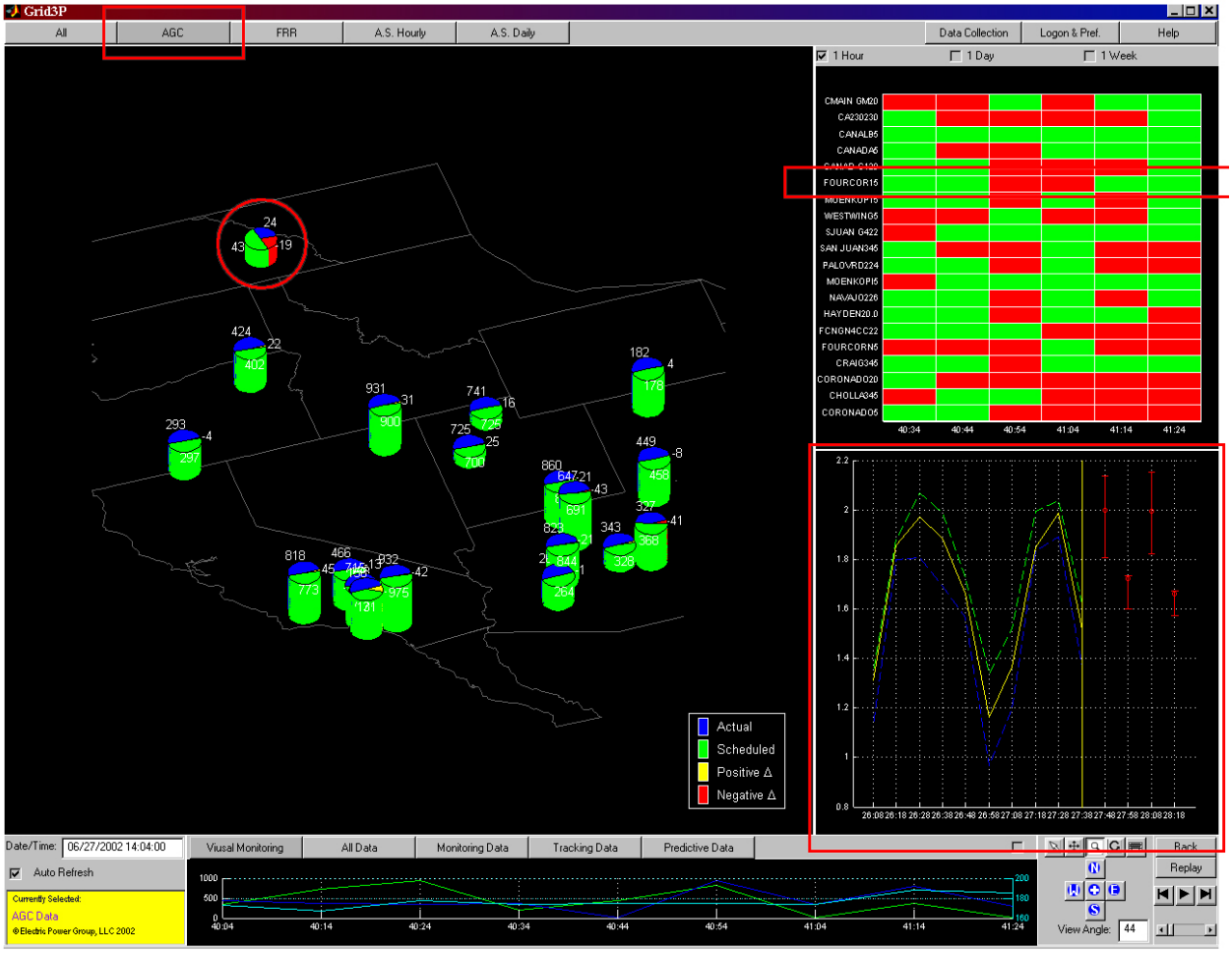


Figure 9. AGC Prediction display status

12. Database design for AGC

The static data is stored in a text file. Only the dynamic data is stored in a RDMS database (SQL Server).

Master table : for the 1 min. data records.

The number of records stack up as follows over the course of a week (archive) –

1 Hour : 60 records

1 Day : 1440 records (60 x 24)

1 Week : 10080 records (60 x 24 x 7)

When number of Generating Units are considered, then the records for each minute go up by the number of units. (* considering that the Generating Units can be on or off in any given 1 min. data and hence the table will be sparse)

Index (Min count)	Day	Hour	Exp (MW) E	Act (MW) A	Exp Time (Day, h/m/s)	Act Time (Day, h/m/s)	Δ (A-E)	CPS 1	CPS 2	CA CPS 1	CA CPS 2	$SCPS_1$	$SCPS_2$
1	1	00:00	G1										
2			G2										
3			..										
4			..										
5													
6													
7			Gn										
8		00:01	G1										
9			G2										
10			..										
11			Gn										
12		00:02	G1										
13			..										
14			Gn										
15		..	..										
		00:59	G1										
			..										
..			G2										
		01:00	G1										
			..										
			Gn										
		..	..										
		01:59	G1										
..			..										
			Gn										
		2											
		3											
		..											
		22											
		23											
..	2	0											
		1											
		..											
..		22											
		23											
	3	0											
		..											

		23											
..	**4**	0											
		..											
		23											
	5	0											
		..											
		23											
..	**6**	0											
		..											
		23											
	7	0											
n-4		1											
n-3		2											
n-2		..											
n-1													
n		23											

The entries of Day and Hour are superfluous. The record sets can be accessed based on the record counts shown above.

Pseudo code for database update and data computation for Tracking function

The master index 'i' keeps count of the minute record appended to the master table.

```
while  ( i < 10080 )
 {
    // for last 1 hour tracking averaged over 5 min
    if ( ! ( i % 5 ))
     {
        - Compute Avg of last 5 readings
              Σ j      ÷   5
              j = i
              j = i - 4
        - Push this reading to 5 min table
     }

    // for last 1 day tracking averaged over 2 hr.
    if ( ! ( i % 120 ))
     {
        - Compute Avg of last 120 readings (this can be got from the records in 5 min table)
              Σ j      ÷   120
              j = i
              j = i - 119
        - Push this reading to 2 hr table
     }
```

```
    // for last 1 week tracking averaged over 1 day
    if ( ! ( i % 120 ))
      {
        - Compute Avg of last 1440 readings (this can be got from the records in 2 hr table)
              Σ j      ÷   1440
              j = i
              j = i - 1439
        - Push this reading to 1 day table
      }

    // for prediction averaged over 10 min
    if ( ! ( i % 10 ))
      {
        - Record every 10th reading
        - Push this reading to prediction table
      }

    // maintenance of archive
    if ( time of last record is 00:00 )
      {
        - delete data of day 1 (all records for all Gen Units for first 24 hours in the archive)
        - renumber the days  (the days are numbered 1 – 7 always*)
        - update 5 min, 2 hr and 1 day tracking tables too
      }
  }
```

***** The database will have a record of 8th day beginning 8th day : 00:00 to 8th day : 23:29. Only when it becomes 9th day : 00:00 will the record of the 1st day be deleted.

13. Data Tables for AGC

Data fields for AGC (from PI system processed by the analysis module): Master Table

Index	Exp. (MW)	Exp. Time Stamp (Day, h/m/s)	Act. (MW)	Act. Time Stamp (Day h/m/s)	Delta (Act – Exp) (MW)	CPS1	CPS2	…

Data generated

For tracking the following 3 tables are generated. The structure of each of these tables is –

5min Table / 2Hr Table / 1 day Table

Index	Exp. (MW)	Act. (MW)	Time for period (Day h/m/s)	Delta (Act – Exp) (MW)	CPS1	CPS2	…

For prediction the data is at every 10 min interval

Index	Exp. (MW)	Exp. Time Stamp (Day, h/m/s)	Act. (MW)	Act. Time Stamp (Day h/m/s)	Delta (Act – Exp) (MW)	SD of Delta	…

The predicted value table, which is also archived over every 10 min interval

Index	Exp. (MW)	Exp. Time Stamp (Day, h/m/s)	Pre. (MW)	Act. Time Stamp (Day h/m/s)	Delta (Act – Exp) (MW)	SD of Delta	..

14. Data for FRR

The data will be in 2 sections:

Static – the data regarding Supplier/Plant/Generating Units, which is constant

- Unit / Plant (or load) name and number [~200 Gen Units]
- Type - Thermal / Hydro
- Geographic Location – Latitude & Longitude (North / South)
- Suppliers and the total number plants and total number of units per plant (Plant Name and Unit number)
- Suppliers per control area (Names)
- Any constants and policies regarding the response rates, performance indices
- Initial values of frequency response performance for each unit per output MW segment

Dynamic – *the time dependent data which is collected at different time intervals or computed into groups after getting the raw data*

- Frequency measurement of the system (Hz)
- Time stamp of frequency excursions (Day, h/m/s)
- Frequency measurement for excursion (Hz)
- Expected frequency response performance of each unit/plant per output MW segment
- Power (MW) at each FRR unit at time of excursion (t)
    - t + 20
    - t + 60
- Updated frequency response performance of each unit/plant per output MW segment

15. FRR Monitoring Display

FRR monitoring screen would be as shown in Figure 10.

Just as in the case of AGC monitoring, in the FRR monitoring panel the Expected (E-Fr) and Actual (A-Fr) frequencies of the generating unit will be displayed as the two halves of a circle centered at the Lat/Long of the generating unit/plant - as a pie-graph. Both E-Fr and A-Fr form the semi circles and fill the sector based on the values displayed. Any difference will be shown as a sector instead of a full semi circle (this is mostly for the actual generated value)

Just as in the case of AGC these pie-graphs will be displayed based on a variety of selection criteria chosen by the user through the RMB.

- Entire Control area (all generating units of both types of all suppliers in all geographic locations)
- Geographic locations – North or South
- A supplier
- Thermal or Hydro
- A plant of a supplier
- Any individual generating unit within a plant

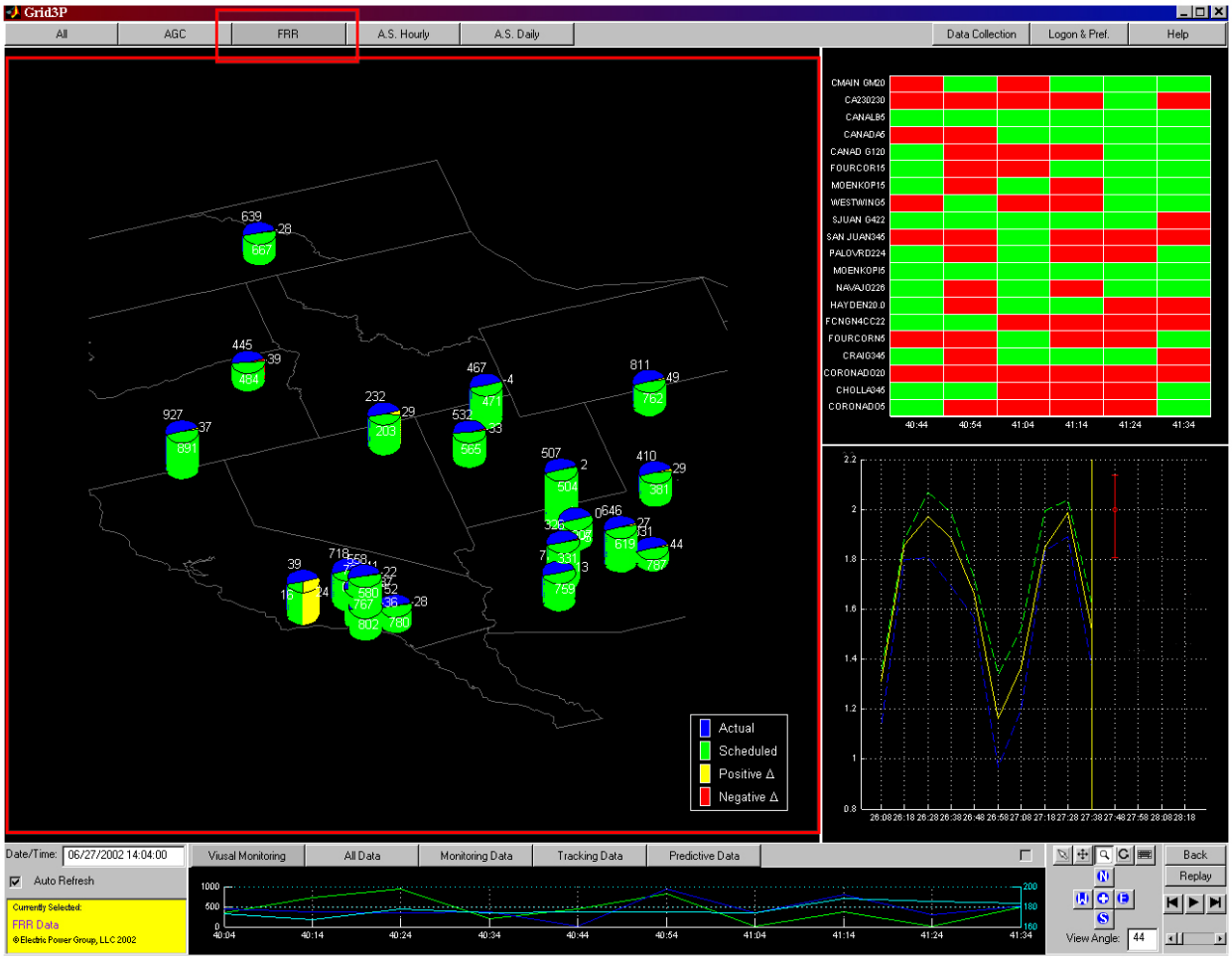


Figure 10. Monitoring display of FRR

This selection criterion will be based on multiple-choice criteria. The user can select any of the check boxes from the above list. The menu structure of the FRR Monitoring RMB will be as shown in Figure 11.

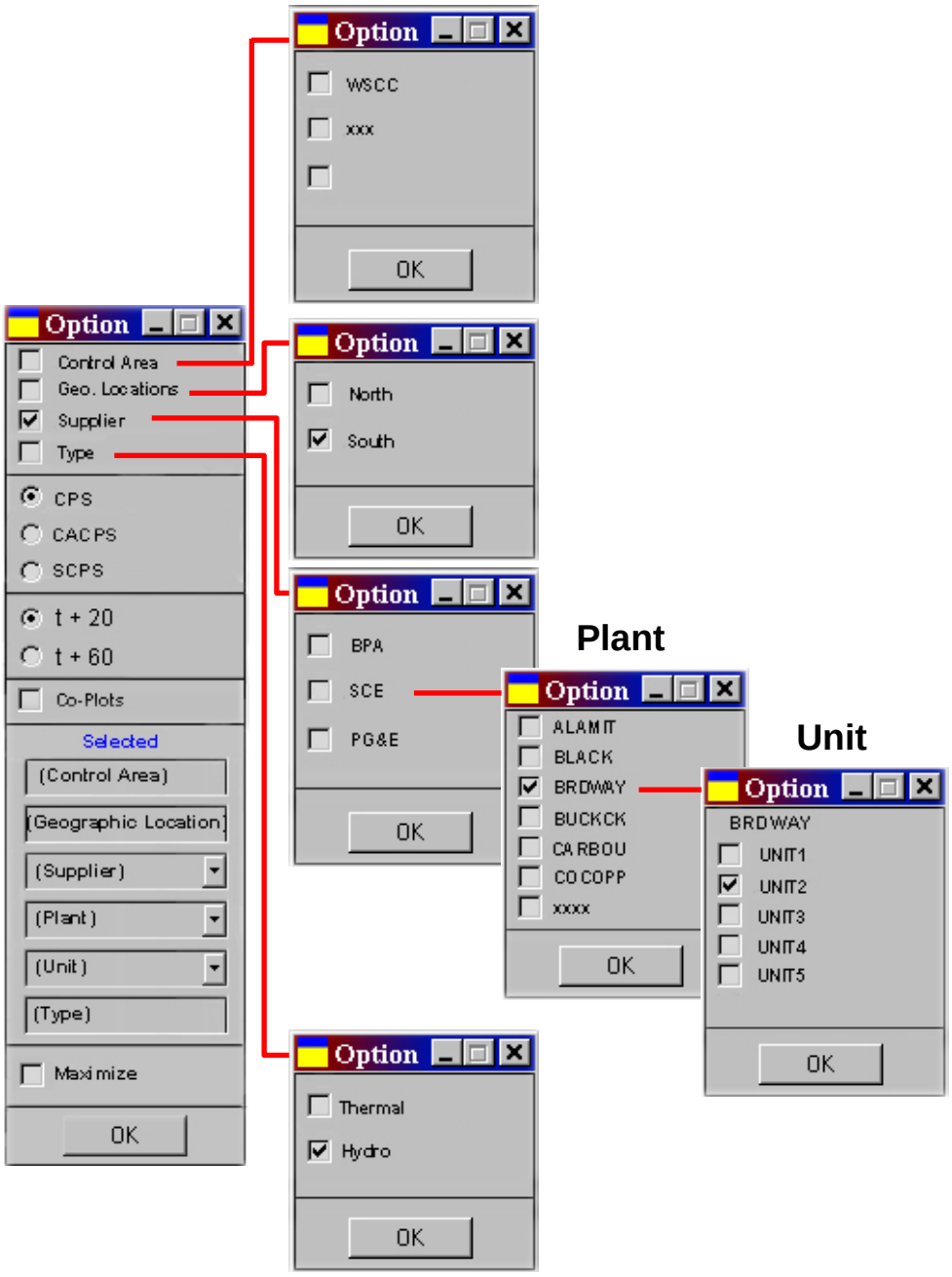


Figure 11. Right Mouse Button Menu Structure for FRR

Once the generating units have been selected, then comes the issue of displaying their performance by a Performance Index (PI). The magnitude of PI is shown as the height of pie-graph.

Since there is no information displayed of the generating units on any of the panels, there will be a point- and-click selector which will show all the information of a generator like – name, type, supplier, lat/long, expected, actual, PI (based on the type of PI shown), etc.

Figure 12 describes this context of the system.

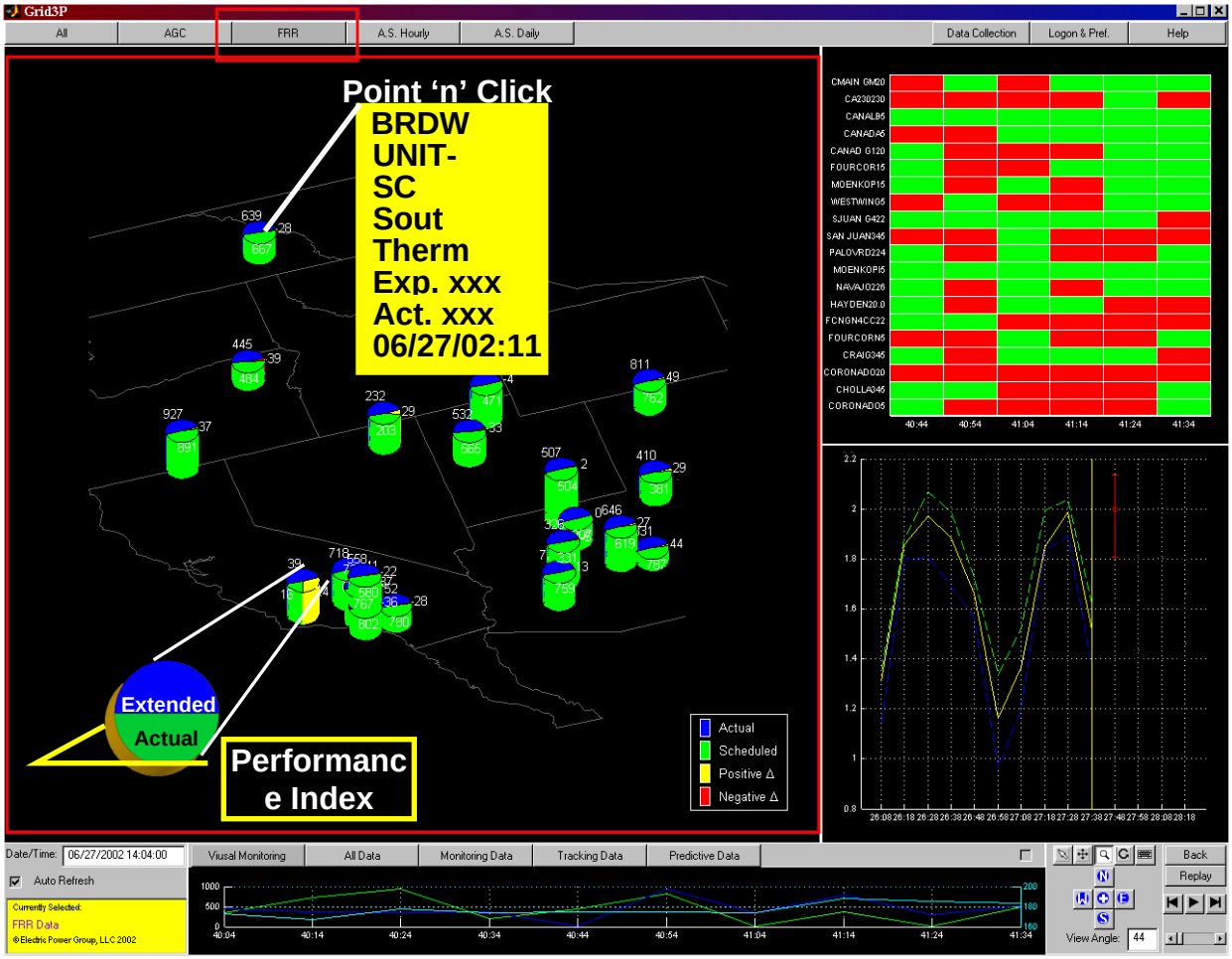


Figure 12. FRR Performance Index and Generating Unit Information

16. FRR Tracking Display

Tracking information will be shown for user selected event counts (frequency excursion events) from the historical data from the current time backwards. The plot is an E-Mesh with the Generation Units on the Y-Axis and the events on the X-Axis. The value plotted will be the Frequency Response or the Performance Index at each excursion. Also in this case the user can select the range for which the data is to be displayed. These selections will be done through a RMB. This E-Mesh plot will be similar to that shown in figure 12.
The user would select the number of events for which the plot is displayed through a pop-up dialog box – an event of the RMB. All the frequency response data as shown in the data table in section 14.0 at every excursion will be archived.

17. FRR Prediction Display

The plot will show the following for any one of the selected Generating Unit in the bottom right panel:

- Actual frequency response values for the user selected number of past excursion events from the current time
- Predicted frequency response values of excursions for the user selected number of events (as above)
- Prediction of the frequency response for the next excursion (only one value) with probability bands with upper and lower values.

The user can select the generating unit from the monitoring display or a RMB can be provided. When the prediction is displayed the selected Generating Unit will be highlighted both in the monitoring panel and the tracking panel. The display will be as shown in similar to that in figure 13.

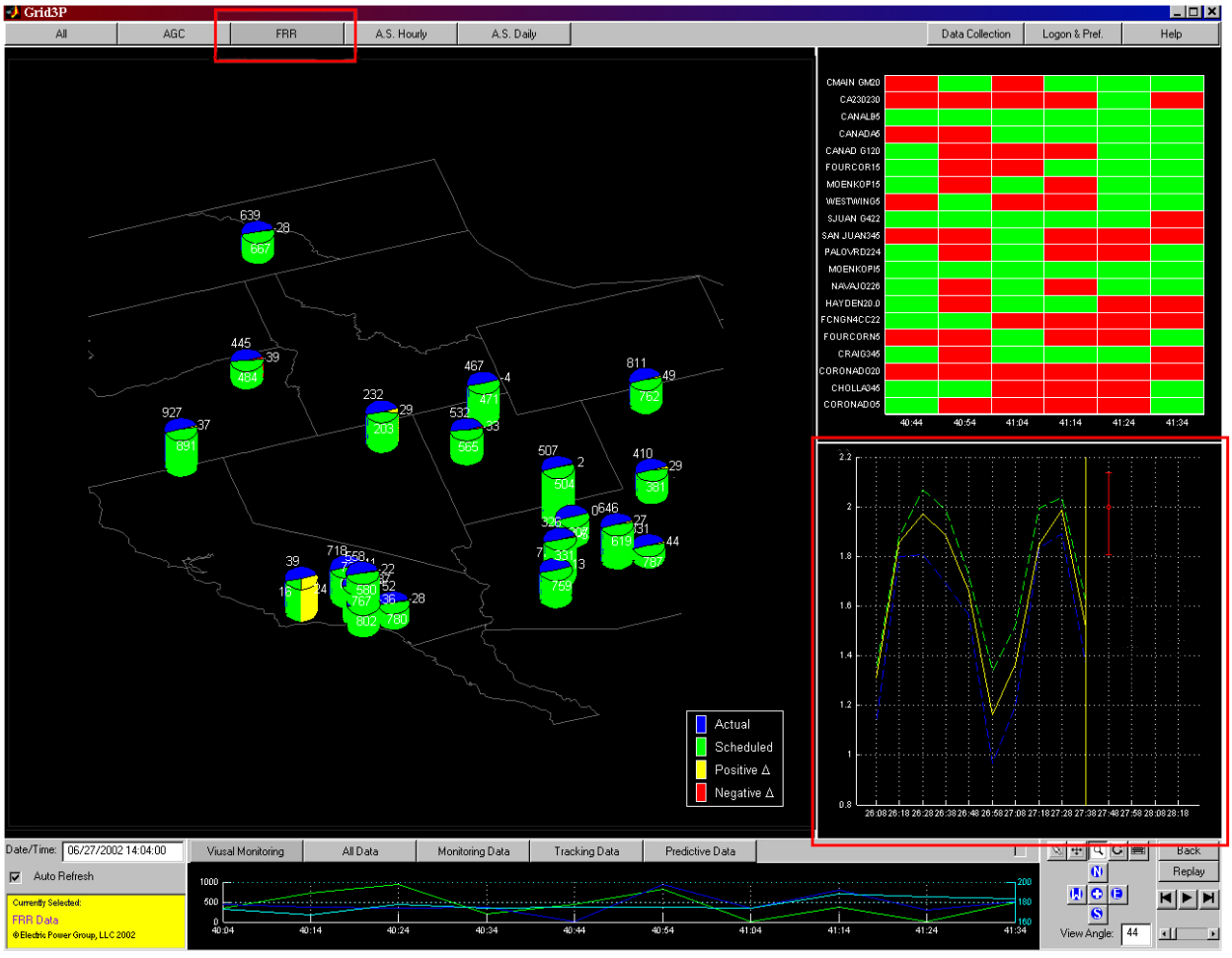


Figure 13. FRR Prediction display status

18. Database design for FRR

The static data is stored in a text file. Only the dynamic data is stored in a RDMS database (SQL Server).

The FRR data will be in 2 tables. The structure will be as shown below.

Data of the specific excursion event

FRR ID	Date / Time (Day, h/m/s)	Frequency (Hz)

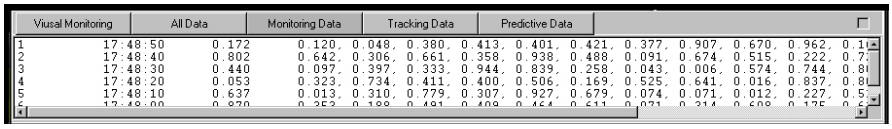
Data of all the generating units due to the excursion

ID	FRR ID	Gen value at t (MW)	Time (Day, h/m/s)	Range 1 Power		Range 2 Power		Range 3 Power		Range 4 Power	
				t+20	t+20	t+20	t+60	t+20	t+60	t+20	t+60

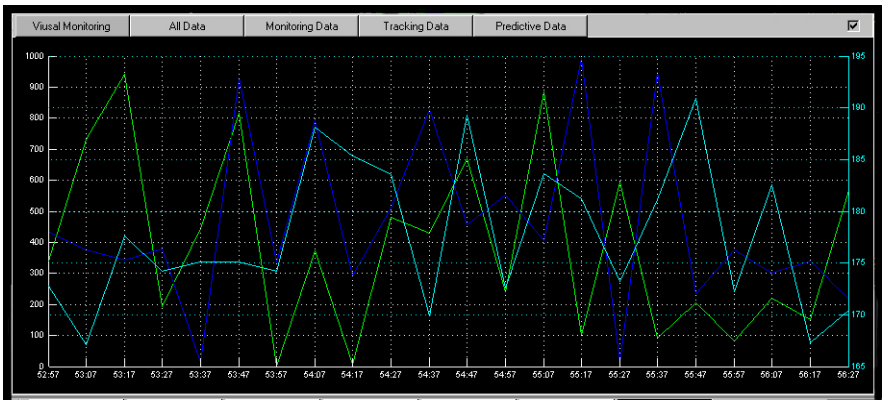
where 't' is the time of excursion

19. Text window with scrolling performance index plots

The text window will display the data in a tabular format. The data displayed will be based on the context of the current service and function selected. Figure 14 shows the display with the text and the horizontal scrolling plots of the Performance Indices. This window is a spring-up window, by which the user can visualize a larger amount of data at a time, by toggling a check box. For e.g., in figure 14 the text data is shown in a folded state where as the plot scroll is shown in a spring up state.



Text Data Window



Dvnamic Horizontal Scroll Window

Figure 14. Text window and the scrolling PI plot

In the same window the PI for the service is displayed as a scrolling bar for the time interval chosen by the user. Also through the RMB the user can select the type of PI he wants displayed, i.e., CPS*, CACPS* or SCPS* for AGC, PI for FRR. By default the performance index scrolled will be for the Generating Unit chosen in the monitoring panel. Also by the RMB dialog menu the user can select PI for CA or PI for Supplier to be displayed. The window will also display the Unit ID (of the selected unit) and the Type of PI being displayed.

20. Conditional-Plots for AGC, FRR or AS

Conditional plots (Co-Plots) will be shown in the Main Panel (MP). The co-plots option is selectable from the RMB dialog box in monitoring and they will be shown with reference to only the units (Generating Unit) displayed in the monitoring panel just prior to selecting the co-plot option. Option to select different co-plots is available through the RMB dialog for the Co-Plot panel. The number of plots will be arranged in a grid fashion left to right and top to bottom with the parameters being displayed sorted by a configurable statistic such as their mean value. If the number of units in the monitoring panel is large then the Co-Plots will display the plots for only ten of the units with the largest absolute Δ's. Figure 15 shows a co-plot display.

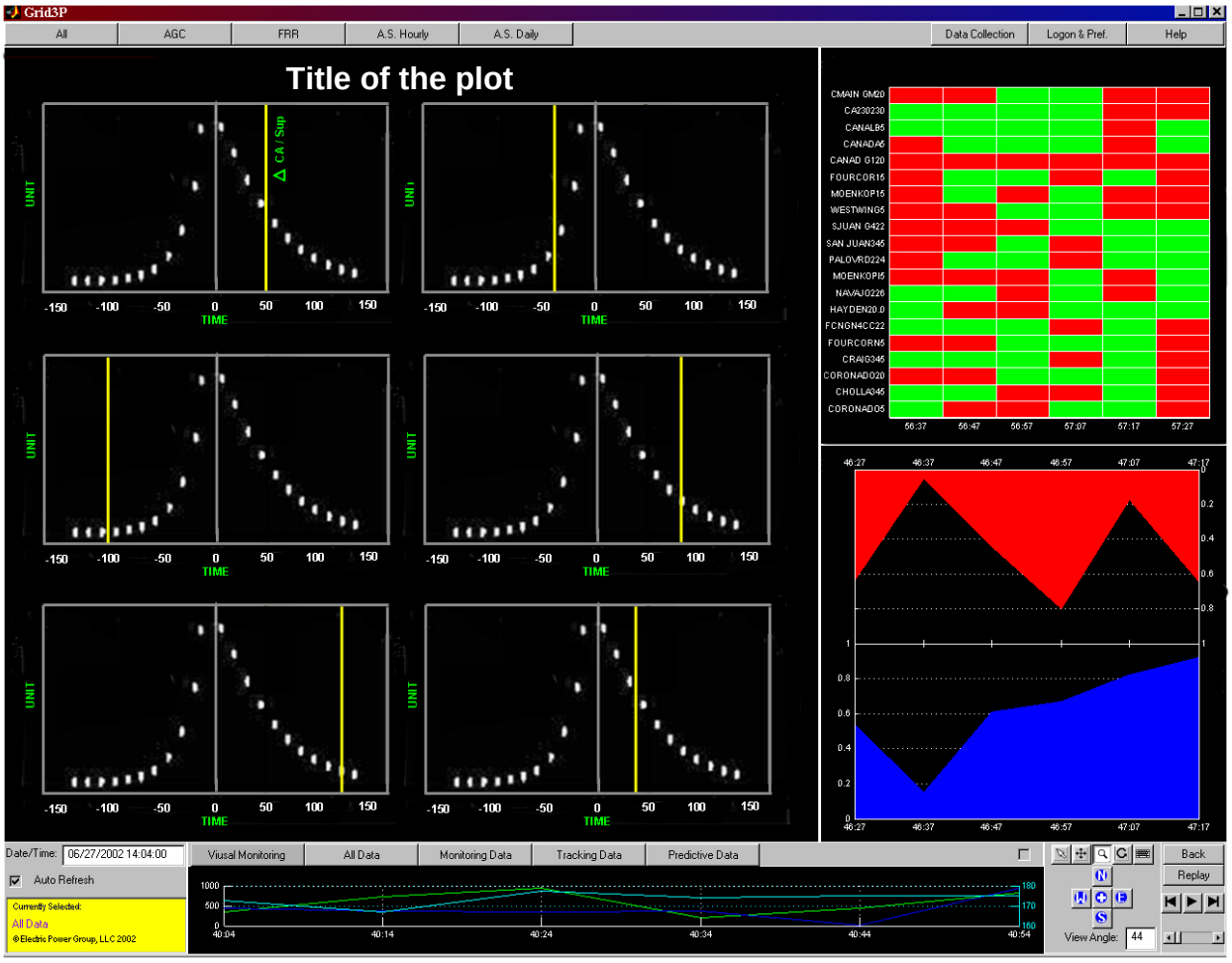


Figure 15. Co-Plot display

All the Co-Plots are plotted in the same fashion for all the three services – AGC, FRR and AS. For each service a variety of co-plots can be selected using data in different manner. Each of these co-plots is explained below.

For AGC :

Control Area (CA) Co-Plot – this is the default co-plot of the control areas for 12 five minute periods (one hour), going from the most recent to the latest, left to right and top to bottom. The plot will consist of the ACE of the CA and the Δ's (Actual – Expected) of all units in that CA. The generating units will be on the vertical axis and the Δ's of the units on the abscissas. The

title of the plot will consist of – ACE (MW) of the CA and an identifier of the time period corresponding to the plot.

Supplier Co-Plot – same as Control Area Co-Plot above.

Sorted Co-Plots – for the past hour the maximum and minimum ACE values are identified and this range is divided into 12 values and sort in ascending order. For each of these values, the time period in which the ACE occurred will be identified. The title of the plot will include ACE value and time period of occurrence. Units will be on the vertical axis and the Δ's on the abscissas.

In each of the above co-plots the value of the Control Area ACE will be represented as a vertical line of different color.

For FRR :

These co-plots will be for 't + 20' or 't + 60' frequency response values. The default is 't + 20'. The user can select this by RMB menu. On the vertical axis will be the generating units and on the abscissa will be either 'Actual Response' or Δ (Actual – Expected). The data plotted for each unit will be either '%' or MW / 0.175 Hz. Here again the user can select one of the four MW ranges for the response values. The default co-plot will be for all the units on the monitoring panel, MW Range 1, actual response and MW/0.175Hz.

In the Right Top Panel (RTP) E-Mesh data will be displayed as displayed in the Tracking function of AGC and FRR. The data displayed will be the Δ, PI or Frequency Response based on the service (AGC, FRR or AS).

In the Right Bottom Panel (RBP) the data will be displayed as a 'Cave Plot'. In this plot 2 values are plotted one above the other with the top one plotted in a top-down fashion. The top plot will display the actual MW and the bottom plot the expected MW output of the selected generating unit in AGC. In the case of FRR the top plot will display the actual frequency response and the bottom plot will display the expected frequency response for the selected unit.

21. Data collection module

This is the 'Engineer's Module'. As the name indicates, this module is used by the engineers or supervisors. Through this module an engineer can monitor the state of the system for any time period using the archived data – look at the behavior of any CA, supplier, plant or even an individual unit. The engineer selects the parameters from a dialog box as shown in figure 16. Once the data is selected then the engineer can see the data presented as conditional plots for the chosen parameters similar to that shown in figure 15 above. This module also allows the user to store the data of the generating units, which would be selected based on the selection criteria in a CSV file in a designated directory for reference.

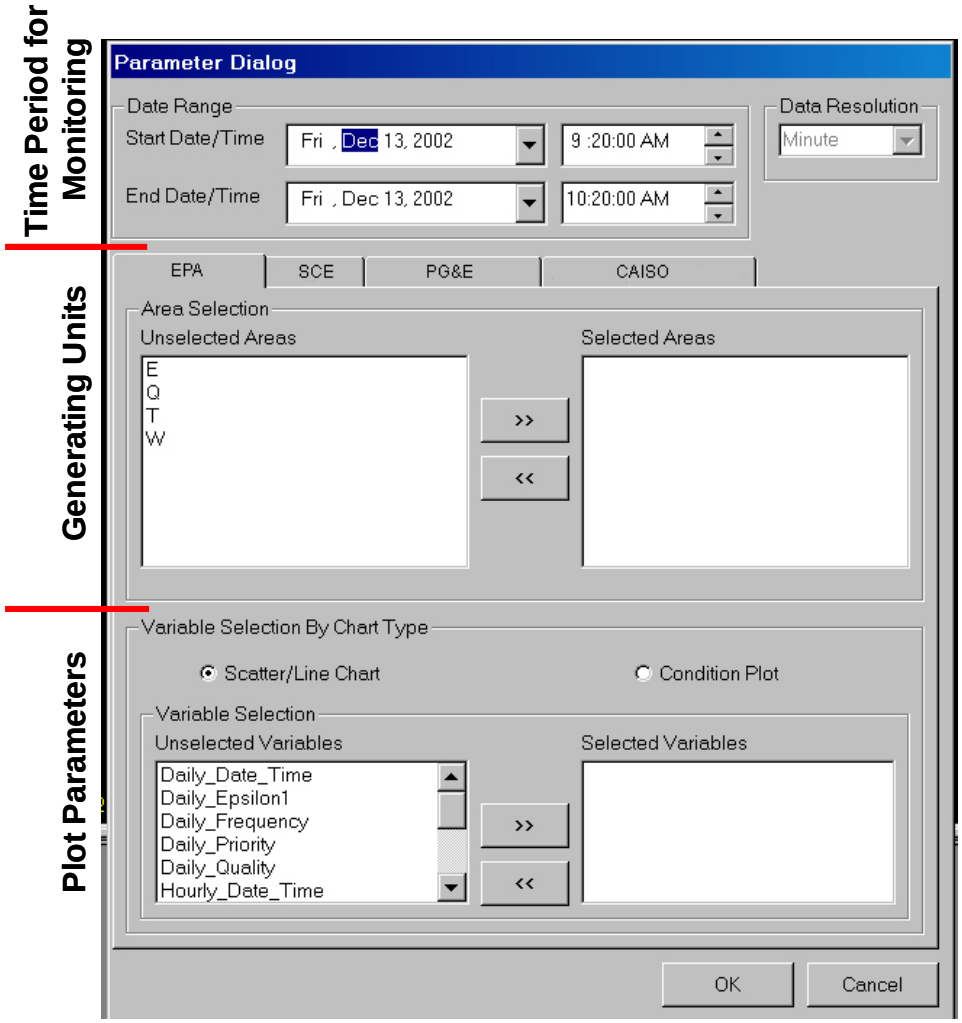


Figure 16. Parameter dialog window for AGC and FRR data collection module

22. Displays for the Ancillary Services

In the case of the Ancillary Services (both hourly and daily) the displays will be similar to those in AGC. For monitoring the pie-graphs will display the expected and the bid values of the suppliers. The pie-graph height depicts the performance index. In the tracking panel the Δ or the performance index will be shown. And in the prediction panel the prediction value will be shown for a unit selected from any one of the units on the monitoring panel.

23. Replay function

For AGC and FRR the user will have the ability to replay for any interval of time / excursion events for, which the archival data is available – 1 week for AGC and AS and 6 months for FRR. This is the same data that is collected in real time, which appears on the corresponding monitoring, tracking and prediction panels. The replay can be controlled by the user by selecting the time resolution and for the time interval requested by the user. The time interval and resolution is input through a pop-up window, selected through the replay keys in the navigation pad.

Figure. A-1 Code Flow

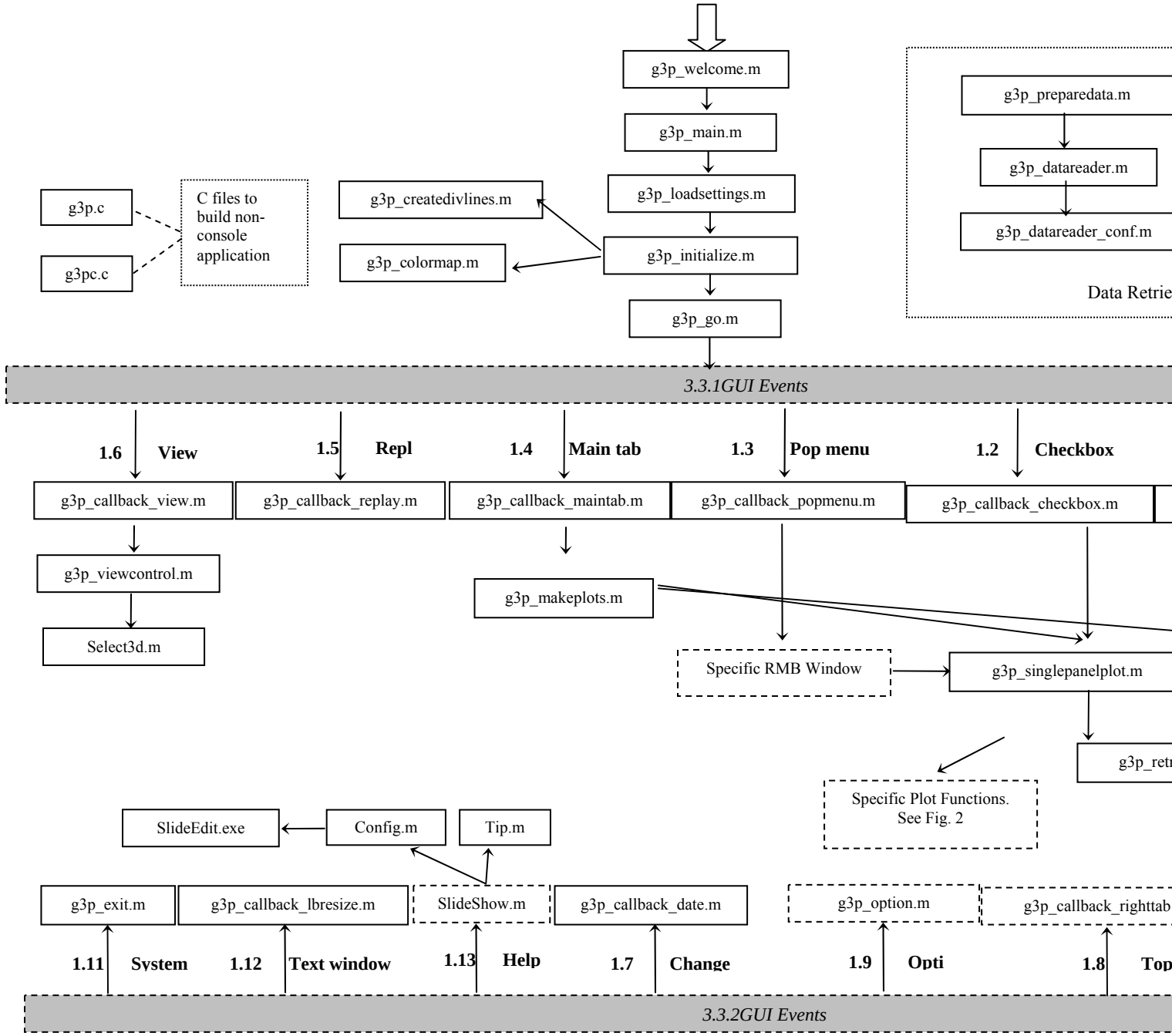
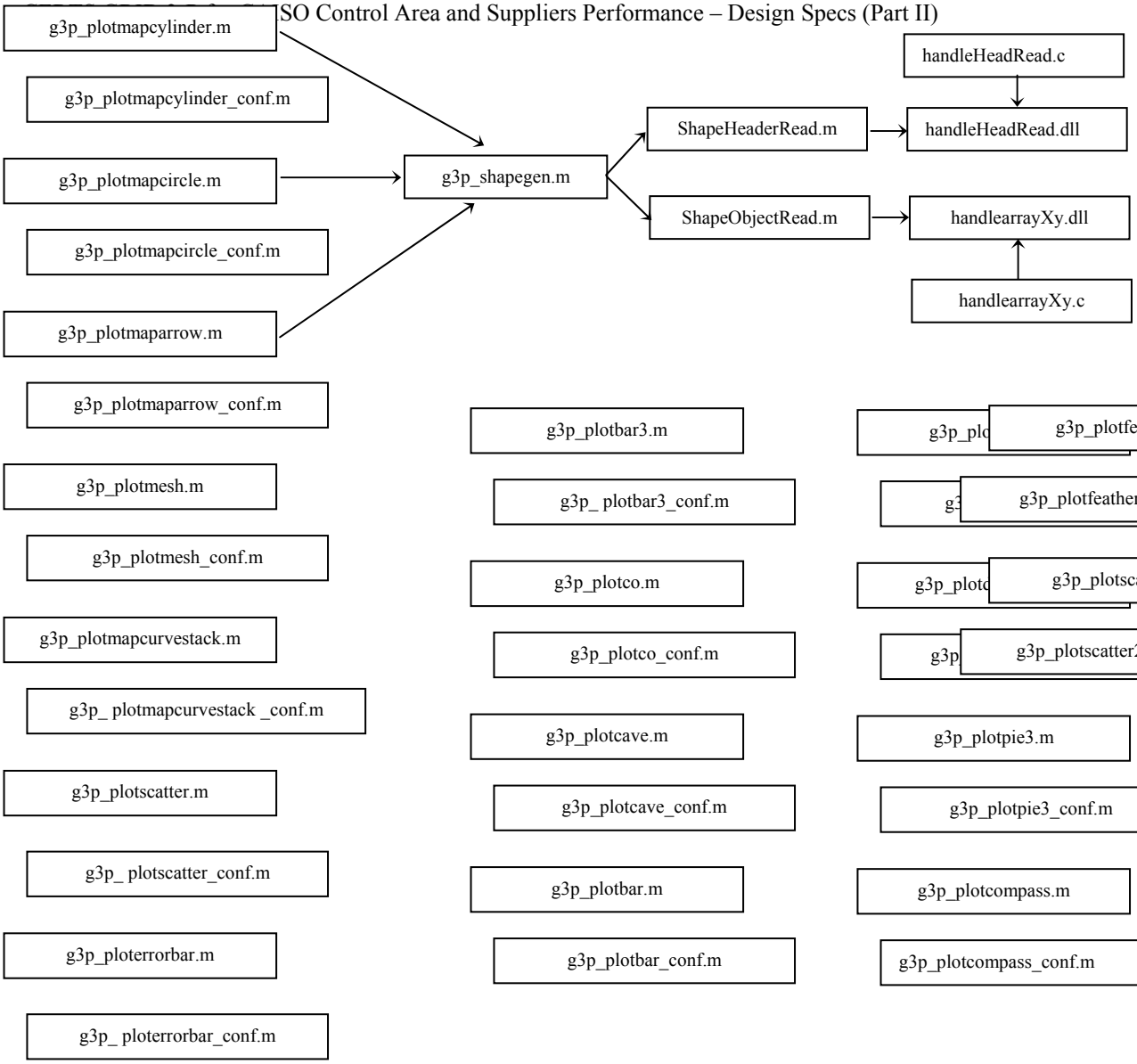


Figure. A-2. Configurable plots (17 plots in total)


g3p_plotmapcylinder.m
g3p_plotmapcylinder_conf.m
g3p_plotmapcircle.m
g3p_plotmapcircle_conf.m
g3p_plotmaparrow.m
g3p_plotmaparrow_conf.m
g3p_plotmesh.m
g3p_plotmesh_conf.m
g3p_plotmapcurvestack.m
g3p_ plotmapcurvestack _conf.m
g3p_plotscatter.m
g3p_ plotscatter_conf.m
g3p_ploterrorbar.m
g3p_ ploterrorbar_conf.m
g3p_shapegen.m
ShapeHeaderRead.m
ShapeObjectRead.m
handleHeadRead.c
handleHeadRead.dll
handlearrayXy.dll
handlearrayXy.c
g3p_plotbar3.m
g3p_ plotbar3_conf.m
g3p_plotco.m
g3p_plotco_conf.m
g3p_plotcave.m
g3p_plotcave_conf.m
g3p_plotbar.m
g3p_plotbar_conf.m
g3p_plotfeather.m
g3p_plotfeather_conf.m
g3p_plotscatter2.m
g3p_plotscatter2_conf.m
g3p_plotpie3.m
g3p_plotpie3_conf.m
g3p_plotcompass.m
g3p_plotcompass_conf.m

24. Appendix

M Files For AGC, FRR, AS – Monitoring and Regulation

g3p_welcome.m
Start point of application. This file displays a welcome image. Click on the image will start specific application.

g3p_main.m
Entry point for specific application. It reads in configurations, and store them into system momories, and visualize the data as if first tab is clicked.

g3p_loadsettings.m
Reads in configurations.

g3p_initialize.m
Initialize GUIs based on the configuration. It loads in a colormap for graphic plotings, initializes buttons and theire callbacks, creates lines to divide plot area, and maximizes the application window.

g3p_colormap.m
Defines a color map for the application.

g3p_createdivlines.m
Create two panel divident lines. Panels' positions are calculated.

g3p_go.m
Atuomatically update data buffer. Automatically update plots if necessary.

g3p_callback_view.m
Call back function for view operation buttons: pick, pan, zoom, rotate, and side view of axes. Elevation view angle input.

g3p_viewcontrol.m
The implementation of 3D view control: pick, pan, zoom, and rotate by mouse or keyboard.

select3D.m
Determines the selected point in 3-D data space.

g3p_callback_replay.m
Implements replay callback function, including functions: go to first, go to last, go to particular case, forward/backward replay, and return to real time data when replay finishes.

g3p_callback_maintab.m
Call back function for main tab buttons (top left tabs). This file firstly reset/redraw checkbox if needed. Then draw specific plots and update text window if necessary. The plots are defined in the configuration file.

g3p_callback_popmenu.m
Display specific popup window according to configuration. Process its compents' callback functions.

g3p_callback_checkbox.m
Implement the callback of three checkbox groups for particular visual panels. Update checkbox's status and plot for a specific panel.

g3p_callback_bottomtab.m
Display columns of data in list box control or display dynamic scroll plot at the central bottom. Switch text-window to dynamic scroll the plot window.

g3p_callback_righttab.m
Callback function for right tabs. It's optional according to configuration.

g3p_callback_toprighttab.m
Callback function for top right tabs. It's optional according to configuration.

g3p_exit.m
Clean the application and exit.

g3p_callback_lbresize.m
The callback function to resize the text window at central bottom.

SlideShow.m
Generate help window, and implement callbacks of buttons on the window. Functions include auto-play the slides, go to first/last slide, set play interval time, et al. It's optional.

SlideEdit.exe
An excutable file for slide configuration, such as select images into the help display, arrange the image order, et al. The results are saved into files with extention of ml. imglist.ml is an example.

Tip.m
Show tips for SlideShow gui.

Config.m
To configure slide display: the image list file name, autoplay or not, loop when meet the last slide, and show tips or not. The result will be saved out into file SlideShow.ini.

g3p_callback_date.m
Callback function for client users to select specific date and update data buffer.

g3p_option.m
Callback function for client users to set its options. It's optional.

g3pmakeplots.m
Plot graphics according to configuration. It dertimines which data should be drawed on which panel. It calls g3p_singlepanelplot.m.

g3p_singlepanelplot.m
Draw specific plot onto a particular panel.

g3p_retrieveplotdata.m
Retrieve data for plotting or displaying at text window according to currently activated buttons and/or RMB popup window.

g3p_preparedata.m
Call g3p_datareader.m to read the data from data source and store the data into data buffer.

g3p_datareader.m
Read data from data source. The data are categorized into groups. Every group can have columns of data with the same format. It will call other functions specific to different data source: file, database or others.

g3p_datareader_conf.m
Configure the parameters for data reader.

g3p_shapegen.m
Load and draw a shape file on to current axes.

ShapeHeaderRead.m
Read the shapefile's header information. It called function HandleHeadRead defined in handleHeadRead.dll.

handleHeadRead.dll & handleHeadRead.c
Convert shape's header data into arrays. It is compiled from HandleHeadRead.c.

ShapeObjectRead.m
Read the shape file's geometry objects. It called function HandlearrayXY defined in handleHeadRead.dll.

handlearrayXy.dll & handlearrayXy.c
Convert shape object's X, Y, Z data into arrays. It is compiled from HandleArrayXY.c.

g3p_plotmapcylinder.m & g3p_plotmapcylinder_conf.m
g3p_plotmapcylinder.m displays the current response of each generator (T13). g3p_plotmapcylinder_conf.m opens a window with default settings (loading from g3p_plotmapcylinder_conf.dat) to configure the settings for map-cylinder plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotmapcylinder_conf.dat.

g3p_plotmesh.m & g3p_plotmesh_conf.m
g3p_plotmesh.m displays the performance tracking of each generator (T14). g3p_plotmesh_conf.m opens a window with default settings (loading from g3p_plotmesh_conf.dat) to configure the settings for mesh plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotmesh_conf.dat.

g3p_plotcurvestack.m & g3p_plotcurvestack_conf.m
g3p_plotcurvestack.m displays the predictive plot (T15). g3p_plotcurvestack_conf.m opens a window with default settings (loading from g3p_plotcurvestack_conf.dat) to configure the settings for stacked curve plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotcurvestack_conf.dat.

g3p_plotmapcircle.m & g3p_plotmapcircle_conf.m
g3p_plotmapcircle.m displays the FRR plot (T20). g3p_plotmapcircle_conf.m opens a window with default settings (loading from g3p_plotmapcircle_conf.dat) to configure the settings for map-circle plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotmapcircle_conf.dat.

g3p_plotscatter.m & g3p_plotscatter_conf.m
g3p_plotscatter.m displays the FRR performance tracking plot (T21). g3p_plotscatter_conf.m opens a window with default settings (loading from g3p_plotscatter_conf.dat) to configure the settings for regular scatter plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotscatter_conf.dat.

g3p_plotberrorbar.m & g3p_ploterrorbar_conf.m
g3p_ploterrorbar.m displays the FRR performance and variance plot (T22). g3p_ploterrorbar_conf.m opens a window with default settings (loading from g3p_ploterrorbar_conf.dat) to configure the settings for error bar plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_ploterrorbar_conf.dat.

g3p_plotbar3.m & g3p_plotbar3_conf.m
g3p_plotbar3.m displays the supplier control performance tracking plot (T23). g3p_plotbar3_conf.m opens a window with default settings (loading from g3p_plotbar3_conf.dat) to configure the settings for 3D bar plot. OK button returns the

setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotbar3_conf.dat.

g3p_plotco.m & g3p_plotco_conf.m
g3p_plotco.m displays the conditional plot for any services selected (T24). g3p_plotco_conf.m opens a window with default settings (loading from g3p_plotco_conf.dat) to configure the settings for coplot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotco_conf.dat.

g3p_plotcave.m & g3p_plotcave_conf.m
g3p_plotcave.m displays MW response (T25). g3p_plotcave_conf.m opens a window with default settings (loading from g3p_plotcave_conf.dat) to configure the settings for cave plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotcave_conf.dat.

g3p_plotbar.m & g3p_plotbar_conf.m
g3p_plotbar.m displays part of (T26). g3p_plotbar_conf.m opens a window with default settings (loading from g3p_plotbar_conf.dat) to configure the settings for bar plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotbar_conf.dat.

g3p_plotcurve.m & g3p_plotcurve_conf.m
g3p_plotcurve.m displays part of (T26). g3p_plotcurve_conf.m opens a window with default settings (loading from g3p_plotcurve_conf.dat) to configure the settings for curve plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotcurve_conf.dat.

g3p_plotdeviation.m & g3p_plotdeviation_conf.m
g3p_plotdeviation.m displays part of (T26). g3p_plotdeviation_conf.m opens a window with default settings (loading from g3p_plotdeviation_conf.dat) to configure the settings for deviation plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotdeviation_conf.dat.

g3p_plotpie3.m & g3p_plotpie3_conf.m
g3p_plotpie3.m displays part of (T26). g3p_plotpie3_conf.m opens a window with default settings (loading from g3p_plotpie3_conf.dat) to configure the settings for pie3 plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotpie3_conf.dat.

g3p_plotmaparrow.m & g3p_plotmaparrow_conf.m
g3p_plotmaparrow.m displays the PMU/Phasor Data plot (T33). g3p_plotmaparrow_conf.m opens a window with default settings (loading from

g3p_plotmaparrow_conf.dat) to configure the settings for map-arrow plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotmaparrow_conf.dat.

g3p_plotcompass.m & g3p_plotcompass_conf.m
g3p_plotcompass.m displays the voltage/currents with a reference value for each Phasor (T34). g3p_plotcompass_conf.m opens a window with default settings (loading from g3p_plotcompass_conf.dat) to configure the settings for compass plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotcompass_conf.dat.

g3p_plotfeather.m & g3p_plotfeather_conf.m
g3p_plotfeather.m displays the selected voltage vector (T37). g3p_plotfeather_conf.m opens a window with default settings (loading from g3p_plotfeather_conf.dat) to configure the settings for feather plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotfeather_conf.dat.

g3p_plotscatter2.m & g3p_plotscatter2_conf.m
g3p_plotscatter2.m displays the selected voltage vector (T44). g3p_plotscatter2_conf.m opens a window with default settings (loading from g3p_plotscatter2_conf.dat) to configure the settings for scatter2 plot. OK button returns the setting. Cancel button cancels the action. Save As Default button saves the current configurations as default back into file g3p_plotscatter2_conf.dat.

Note: the configurations about above 17 plots share the same format: general configuration (plot type, plot name, etc), data related configuration (data post processing, color coding rules, etc), axes related configuration (plot title, ticks, etc), and geometry object related configuration (line width, line type, etc).

g3p.c
A C file to build a windowed application.

g3pc.c
A C file to build a windowed system configuration application.

M Files and C Files For AGC, FRR, AS – System Configuration

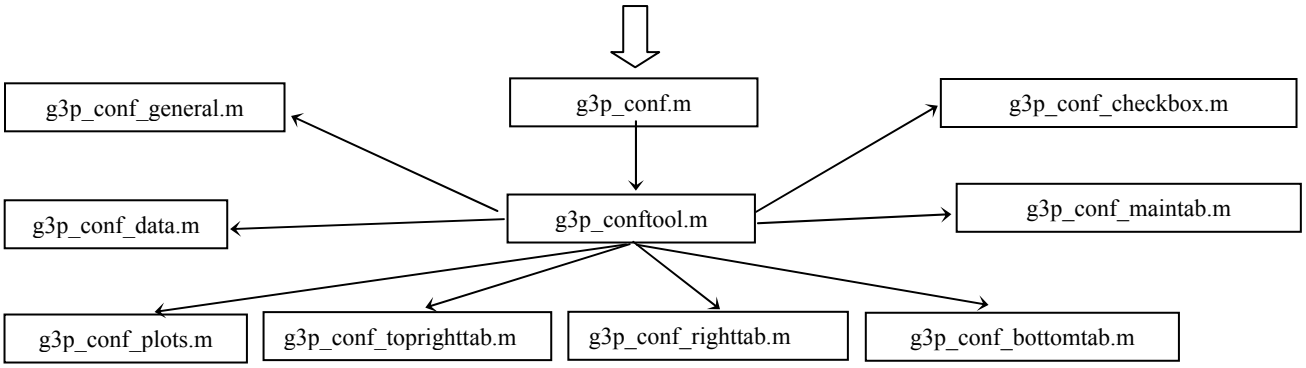


Figure A-3. Code Flow For System Configuration

g3p_conf.m
Entry point of configuration application.

g3p_conftool.m
A callback dispatching file.

g3p_conf_general.m
Open a window to configure general information such as window names, panel horizontal dividend ratio, renderer, etc.

g3p_conf_data.m
Open a window to configure data source, data reading function, etc.

g3p_conf_plots.m
Open a window to configure plots, including plot function, plot source data definition, and plot attributes. The plot attributes are obtained by executing g3p_plot*_conf.m files.

g3p_conf_checkbox.m
Open a window to configure individual checkbox, including checkbox label, tooltip, plot ID, etc. Those checkboxes will be arranged into checkbox groups to be displayed above three panels.

g3p_conf_maintab.m
Open a window to configure main tabs, including label, tooltip, plotID, checkbox group ID, bottom tab group ID, etc.

g3p_conf_bottomtab.m
Open a window to configure bottom tabs, inlcuding label, tooltip, plotID/textID. Those bottomtabs will be arranged into groups to be used by maintab configuration.

g3p_conf_righttab.m
Open a window to configure right tabs, inlcuding label, tooltip, plotID.

g3p_conf_toprighttab.m
Open a window to configure top right tabs, inlcuding label, tooltip, plotID.

Note: the configuration will be wizard-based.

FIG files & MAT files

FIG files are resource file for individual window. MAT files are binary files for configuration and initialization variables.

Window resource files will be created for configuration dialogs, popup windows, and main display window.

usernotes.fig
Window resource file for User Button. Optional.

Config.mat
Binary file holds initialization parameters to create configuration window for help. Called by Config.m.

Gui.mat
Binary file holds initialization parameters to create configuration information window for help. Called by Tip.m.

Text files

usernotes.txt
A text file to contain user notes information. It's a good place to put important notes about the system. Optional.

license.txt
A text file to contain any information about license.

imglist.ml
A text file contains ordered image file names. Those images are played in help window. This file can be manually edited or with SlideEdit.exe. imglist.ml is called by slidershow.m.

SlideShow.ini
A text file contains configurations to show slides. SlideShow.ini is called by slidershow.m.

Directory structure

C:\Program Files\Electric Power Group\Grid3P\

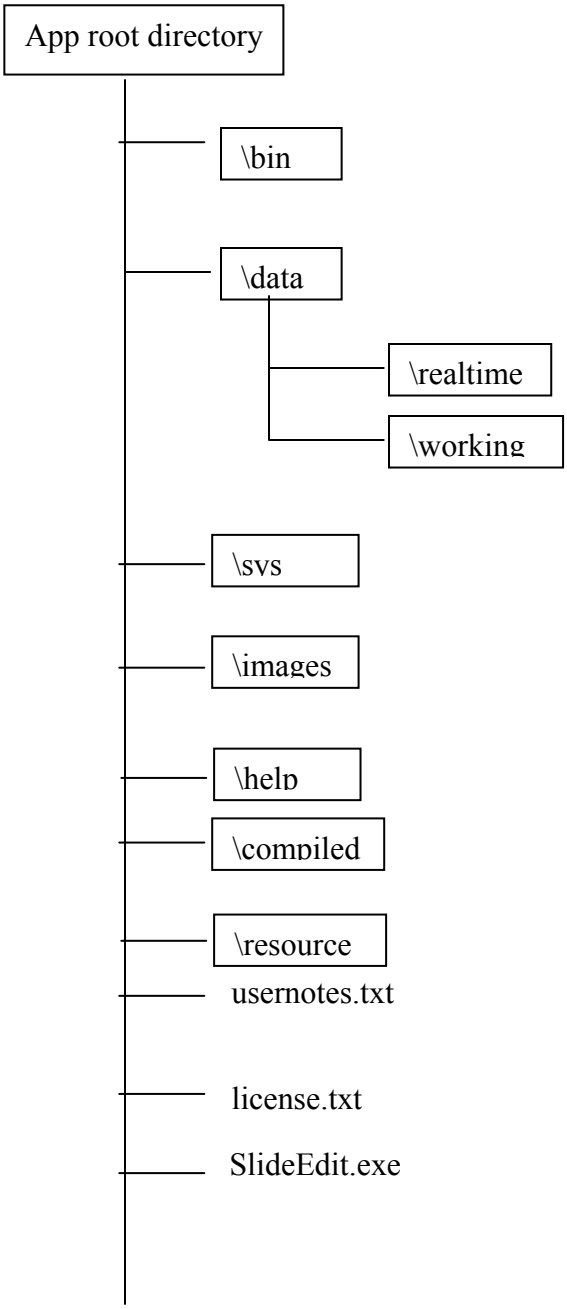


Figure. A-4 Folder

App root directory

It's where application is installed. It's a good place to put executable files compiled from m source code and batch files (for those executable files) there. usernotes.txt, license.txt and SlideEdit.exe should be there. For *Matlab6.1*, the compiled DLLs should be put in this directory. For *Matlab6.5*, the compiled DLLs can also be put in \bin directory. The source m files and C files will be put in this directory too. Those source files will be excluded in the final product version.

\bin directory

A directory automatically created by compiler. It's a good a place to put MATLAB runtime libraries and compiled DLLs files if any (for *Matlab6.5*). Add the directory where MATLAB runtime libraries and compiled DLLs files locate to PATH environment, which can be by users or set in the batch files.

\data directory

A directory to store source data for visualization if in file format.

\sys directory

A directory stores system files and shape files:

(1) MAT files and DAT are binary files for system variables.
(2) FIG files are resource files for dialog windows.
(3) imlist.ml is used to hold ordered image file names for help
(4) SlideShow.ini is used to configure help

\images directory

BMP files, icons used by buttons.

\resource directory

DBF, SBN, SBX, SHP, SHX are shape files.

\help directory

A directory holds images used for help.

\compiled directory

It is destination to place compiled C/C++ code, created DLLs and executables.